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ORDOVICIAN STRATIGRAPHY AND FAUNAS OF THE GLENOGLE FORMATION, SOUTHEASTERN BRITISH COLUMBIA

B.S. Norford, D.E. Jackson, and G.S. Nowlan

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Cover illustration
Northeastern Ridge Section (925NE), part of the Akutlak Composite Section, the standard section of the Glenogle Formation. To the right, top beds of McKay Group, followed upsection to the left by the basal unit, cherty siltstone unit, and lower part of middle unit, all part of the Lower Member of the Glenogle Formation. GSC 4734-1

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ORDOVICIAN STRATIGRAPHY AND FAUNAS OF THE GLENOGLE FORMATION, SOUTHEASTERN BRITISH COLUMBIA

Abstract

The Glenogle Formation (age: Arenig to very early Caradoc) accumulated in the White River Trough between the Purcell Platform to the west and the Bow Platform to the east. The formation is up to 851 m thick, its basal contact is conformable with the McKay Group, and the upper contact is an unconformity below Upper Ordovician rocks that elsewhere cuts down as low as into the Precambrian. The Upper Member of the Glenogle has significant contents of quartz silt and sand within successions of shale in western outcrops and within dolomite in eastern outcrops. The Lower Member is dominantly shale and limy shale but, in eastern outcrops, can be divided into four units (basal, cherty quartz siltstone, middle, and limestone units) by means of incursions of detrital carbonate and siliceous sediments that were swept into the White River Trough from the Bow Platform. Debris flows within western outcrops of the Lower Member demonstrate the presence of shallow-water carbonate rocks on the Purcell Platform during early Llanvirn time. Thermal maturities are high in the Glenogle Formation (Conodont Alteration Indices mostly 4–5; Graptolite Maximum Reflectances 7.93–11.9%).

Graptolites are prominent in the Glenogle Formation and the *Pendeograptus fruticosus-Tetragraptus approximatus*, *Didymograptus bifidus*, *Isograptus victoriae maximus*, *Oncograptus*, *Cardiograptus*, *Paraglossograptus tentaculatus*, *Pseudoclimacograptus decoratus*, *"Glyptograptus" euglyphus* and *Nemagraptus gracilis* zones are recognized and can be correlated with precision with graptolite sequences in Australia, New Zealand, Newfoundland, and Spitsbergen.

The local presence of shelly fossils and recovery of conodonts from a few stratigraphic sections allow correlations between the graptolitic facies of the Glenogle Formation and the Spitsbergen sequence and with the platform facies of the North American craton. The upper part of the Ibexian Series is correlated with the Bendigonian, Chewtonian and lower Castlemanian stages; the *Orthidiella* and *Anomalorthis* zones of the lower Whiterockian Series with the upper Castlemanian, Yapeenian and the Darriwilian stages; and the Valhallan Stage of Spitsbergen with the late Bendiognian to early Darriwilian.

The *Prioniodus elegans* Conodont Zone of the Atlantic Faunal Realm and the *Oepikodus communis* and *Jumudontus gananda-Reutterodus andinus* zones of the Midcontinental Faunal Realm are at least partly correlative with the *D. bifidus* Zone. Conodonts of early Whiterockian age occur with graptolites of the *I. v. maximus* Zone. Conodonts representing the *Histiodella altifrons* Zone occur in the *Cardiograptus* Zone and also just above the graptolites of the *Oncograptus* Zone. Faunas representative of the interval *Lenodus variabilis* Zone to *Eoplacognathus suecicus* Zone are present within the *P. decoratus* Zone and also directly above the *P. tentaculatus* Zone. Faunas with *Phragmodus flexuosus* occur above the *P. decoratus* Zone and below the *"G." euglyphus* Zone. The *Pygodus serra* Zone is represented within the upper part of the *"G." euglyphus* Zone.

Résumé

La Formation de Glenogle (Arénigien-Caradocien très précoce) s'est accumulée dans le rentrant de White River entre la plate-forme de Purcell à l'ouest et la plate-forme de Bow à l'est. Elle atteint 851 m d'épaisseur et repose en concordance sur le Groupe de McKay. Son contact supérieur est une discordance sous des roches de l'Ordovicien supérieur qui, ailleurs, a été érodée jusqu'au Précambrien. Le membre supérieur de la Formation de Glenogle contient des quantités appréciables de silt et de sable quartzeux à l'intérieur de successions de shale dans les affleurements à l'ouest et à l'intérieur de dolomie dans les affleurements à l'est. Le membre inférieur est à prédominance de shale et de shale calcaire, mais peut être divisé, dans les affleurements à l'est, en quatre unités (unité basale, unité de siltstone à quartz cherteux, unité médiane, unité

de calcaire) d'après des apports de sédiments détritiques carbonatés et siliceux qui ont été emportés de la plate-forme de Bow jusque dans le rentrant de White River. Des coulées de débris dans les affleurements ouest du membre inférieur attestent la présence de roches carbonatées d'eau peu profonde sur la plate-forme de Purcell au cours du Llanvirnien précoce. Les maturités thermiques sont élevées dans la Formation de Glenogle (indices d'altération des conodontes généralement de 4 à 5; réflectances maximales des graptolites de 7,93 à 11,9 %).

Les graptolites prédominent dans la Formation de Glenogle. Les zones à *Pendeograptus fruticosus-Tetragraptus approximatus*, à *Didymograptus bifidus*, à *Isograptus victoriae maximus*, à *Oncograptus*, à *Cardiograptus*, à *Paraglossograptus tentaculatus*, à *Pseudoclimacograptus decoratus*, à «*Glyptograptus*» *euglyphus* et à *Nemagraptus gracilis* sont reconnues et peuvent être corrélées avec précision avec des séquences graptolitiques en Australie, en Nouvelle-Zélande, à Terre-Neuve et au Spitzberg.

La présence par endroits de fossiles coquilliers et le prélèvement de conodontes dans quelques coupes stratigraphiques permettent d'établir des corrélations entre les faciès graptolitiques de la Formation de Glenogle et la séquence du Spitzberg et les faciès de plate-forme du craton nord-américain. Sont mises en corrélation la partie supérieure de la série de l'Ibexien avec le Bendigonien, le Chewtonien et le Castlemanien inférieur, les zones à *Orthidiella* et à *Anomalorthis* de la série du Whiterockien inférieur avec le Castlemanien, le Yapeenien et le Darriwilien, et le Valhallien du Spitzberg avec l'intervalle entre le Bendigonien tardif et le Darriwilien précoce.

La Zone à *Prioniodus elegans* du domaine faunique de l'Atlantique et les zones à *Oepikodus communis* et à *Jumudontus gananda-Reutterodus andinus* du domaine faunique médio-continental peuvent être corrélées, du moins en partie, avec la Zone à *D. bifidus*. On rencontre des conodontes du Whiterockien précoce avec des graptolites de la Zone à *I. v. maximus*. Des conodontes représentatifs de la Zone à *Histiodella altifrons* sont présents dans la Zone à *Cardiograptus* et aussi juste au-dessus des graptolites de la Zone à *Oncograptus*. Des faunes représentatives de l'intervalle s'étendant de la Zone à *Lenodus variabilis* à la Zone à *Eoplacognathus suecicus* sont présentes à l'intérieur de la Zone à *P. decoratus* et aussi immédiatement au-dessus de la Zone à *P. tentaculatus*. Des faunes à *Phragmodus flexuosus* se rencontrent au-dessus de la Zone à *P. decoratus* et sous la Zone à «*G.*» *euglyphus*. La Zone à *Pygodus serra* est représentée dans la partie supérieure de la Zone à «*G.*» *euglyphus*.

Summary

The Glenogle Formation was deposited during Arenig to very early Caradoc time in the White River Trough, which separated shallow-water depositional environments of the Purcell Platform to the west and a similar environment of the Bow Platform to the east. At most of the well-known localities, the Glenogle is structurally contorted and stratigraphic sections are incomplete, but recently discovered sections are less deformed and allow elucidation of the formation's stratigraphy and of its succession of graptolite faunas. The formation can be divided into two members, with the lower of these divided locally into four units; the maximum measured thickness is 851 m at the Akutlak Creek Composite Section.

Basinal facies of the Lower Member dominated the central and western parts of the Trough in Bendigonian to Darriwilian time (Arenig to late Llanvirn). In the eastern part, the presence of carbonate and siliceous sediments derived from the Bow Platform permit division of the Lower Member into the basal unit, the cherty quartz siltstone unit, the middle unit, and the limestone unit, and allows relation of the stratigraphy to changes in sea level documented on the Bow Platform. In the western part of the Trough, debris flows from the Purcell Arch transported shallow-water carbonate rocks eastward into the Lower Member. The Upper Member documents shallowing throughout the Trough, commencing within early Gisbornian time (very early Caradoc) and presumably corresponding to the Owen Creek Formation and the superjacent hiatus on the Bow Platform. The Upper Member is characterized by quartz silt and sand mixed with carbonate close to the Bow Platform and with argillaceous material farther west. The top of the formation is an unconformity below

Upper Ordovician rocks that elsewhere cuts down as low as into the Precambrian. Thermal maturities are high in the Glenogle Formation (Conodont Colour Alteration Indices mostly 4–5; Graptolite Maximum Reflectances 7.93–11.9%).

The *Pendeograptus fruticosus-Tetragraptus approximatus*, *Didymograptus bifidus*, *Isograptus victoriae maximus*, *Oncograptus*, *Cardiograptus*, *Paraglossograptus tentaculatus*, *Pseudoclimacograptus decoratus*, *"Glyptograptus" euglyphus* and *Nemagraptus gracilis* zones are recognized and can be correlated with precision with Australia, New Zealand, Newfoundland, and Spitsbergen. The higher zones are known only locally, because of the downcutting of the sub-Upper Ordovician unconformity, and the basal zone was restricted to a small part of the Trough while deposition of McKay Group carbonates continued elsewhere. The local presence of shelly fossils and recovery of conodonts from a few stratigraphic sections allow correlations between the graptolitic facies of the Glenogle Formation with the Spitsbergen sequence and with the platform facies of the North American craton. The upper part of the Ibexian Series is correlated with the Bendigonian, Chewtonian and lower Castlemanian stages; the *Orthidiella* and *Anomalorthis* zones of the lower Whiterockian Series with the upper Castlemanian, Yapeenian and Darriwilian stages; and the Valhallan Stage of Spitsbergen with the late Bendigonian to early Darriwilian.

The recovery of conodonts and graptolites together at a number of levels in the uppermost McKay Group and the Glenogle Formation provides insight into correlation between the two zonal schemes. Conodonts of the Prioniodus elegans Zone of the Atlantic Faunal Realm and of the Oepikodus communis and Jumudontus gananda-Reutterodus andinus zones of the Midcontinental Faunal Realm are at least partly correlative with the Didymograptus bifidus Zone in the uppermost McKay Group and lowermost Glenogle Formation. Conodonts of early Whiterockian age occur with graptolites of the Isograptus victoriae maximus Zone in the cherty quartz siltstone unit. Conodonts representative of the Histiodella altifrons Zone occur just above graptolites of the Oncograptus Zone and together with graptolites of the Cardiograptus Zone in the lower part of the middle unit. Higher in the middle unit, a conodont fauna representative of the interval Lenodus variabilis to Eoplacognathus suecicus zones is present directly above an occurrence of the Paraglossograptus tentaculatus Zone and with graptolites of the Pseudoclimacograptus decoratus Zone. In the limestone unit, faunas with the conodont Phragmodus flexuosus occur above graptolites of the P. decoratus Zone and below those of the "Glyptograptus" euglyphus Zone. The earliest appearance of P. flexuosus is within the Cahabognathus friendsvillensis Zone. The highest direct correlation with the sequence of graptolite zones is near the top of the Lower Member in the Judge Peak Section in the western part of the White River Trough, where conodonts of the Pygodus serra Zone are associated with graptolites that indicate late "G." euglyphus Zone.

Sommaire

La Formation de Glenogle s'est accumulée au cours de l'intervalle de l'Arénigien au Caradocien très précoce, dans le rentrant de White River, qui séparait les milieux de sédimentation en eau peu profonde de la plate-forme de Purcell à l'ouest et un milieu semblable de la plate-forme de Bow à l'est. Dans la plupart des localités bien connues, la Formation de Glenogle présente une structure contournée et les coupes stratigraphiques sont incomplètes. Or, des coupes découvertes récemment sont moins déformées et permettent d'expliquer la stratigraphie de la formation et sa succession de faunes à graptolites. On peut diviser la formation en deux membres, dont le membre inférieur se divise par endroits en quatre unités; l'épaisseur mesurée maximale est de 851 m à la coupe composite d'Akutlak Creek.

Les faciès de bassin du membre inférieur ont dominé les parties centrale et ouest du rentrant pendant l'intervalle du Bendigonien au Darriwilien (Arénigien au Llanvirnien tardif). Dans la partie est, la présence de sédiments carbonatés et siliceux dérivés de la plate-forme de Bow permet de diviser le membre inférieur en une unité basale, une unité de siltstone à quartz cherteux, une unité médiane et une unité de calcaire, et d'associer la stratigraphie à des changements du niveau de la mer relevés sur la plate-forme de Bow. Dans la partie ouest du rentrant, des coulées de débris en provenance de l'arche de Purcell ont transporté des roches

carbonatées d'eau peu profonde vers l'est dans le membre inférieur. Le membre supérieur témoigne d'une diminution de la profondeur de l'eau à la grandeur du rentrant, qui aurait commencé au cours du Gisbornien précoce (Caradocien très précoce) et correspondrait probablement à la Formation d'Owen Creek et au hiatus sédimentaire sus-jacent sur la plate-forme de Bow. Le membre supérieur est caractérisé par du silt et du sable quartzeux mêlés à de la matière carbonatée, près de la plate-forme de Bow, et à de la matière argileuse, plus à l'ouest. Le sommet de la formation est une discordance sous des roches de l'Ordovicien supérieur qui, ailleurs, a été érodée jusqu'au Précambrien. Les maturités thermiques sont élevées dans la Formation de Glenogle (indices d'altération des conodontes généralement de 4 à 5; réflectances maximales des graptolites de 7,93 à 11,9 %).

Les zones à *Pendeograptus fruticosus-Tetragraptus approximatus*, à *Didymograptus bifidus*, à *Isograptus victoriae maximus*, à *Oncograptus*, à *Cardiograptus*, à *Paraglossograptus tentaculatus*, à *Pseudoclimacograptus decoratus*, à «*Glyptograptus*» *euglyphus* et à *Nemagraptus gracilis* sont reconnues et peuvent être corrélées avec précision avec des séquences en Australie, en Nouvelle-Zélande, à Terre-Neuve et au Spitzberg. Les zones supérieures se rencontrent seulement par endroits, en raison de l'érosion verticale de la discordance sous l'Ordovicien supérieur. La zone basale était confinée à une petite partie du rentrant, alors que le dépôt des sédiments carbonatés du Groupe de McKay s'est poursuivi ailleurs. La présence par endroits de fossiles coquilliers et le prélèvement de conodontes dans quelques coupes stratigraphiques permettent d'établir des corrélations entre les faciès graptolitiques de la Formation de Glenogle et la séquence du Spitzberg et les faciès de plate-forme du craton nord-américain. Sont mises en corrélation la partie supérieure de la série de l'Ibexien avec le Bendigonien, le Chewtonien et le Castlemanien précoce, les zones à *Orthidiella* et à *Anomalorthis* de la série du Whiterockien inférieur avec le Castlemanien supérieur, le Yapeenien et le Darriwilien, et le Valhallien du Spitzberg avec l'intervalle entre le Bendigonien tardif et le Darriwilien précoce.

Le prélèvement à la fois de conodontes et de graptolites à un certain nombre de niveaux dans la partie sommitale du Groupe de McKay et dans la Formation de Glenogle donne un aperçu des corrélations entre les structures des deux zones. Les conodontes de la Zone à *Prioniodus elegans* du domaine faunique de l'Atlantique et des zones à *Oepikodus communis* et à *Jumudontus gananda-Reutterodus andinus* du domaine faunique médio-continental ont été corrélés, du moins en partie, avec ceux de la Zone à *Didymograptus bifidus* de la partie sommitale du Groupe de McKay et de la base de la Formation de Glenogle. On trouve des conodontes du Whiterockien précoce avec des graptolites de la Zone à *Isograptus victoriae maximus* dans l'unité de siltstone à quartz cherteux. Des conodontes représentatifs de la Zone à *Histiodella altifrons* sont présents juste au-dessus des graptolites de la Zone à *Oncograptus* et avec des graptolites de la Zone à *Cardiograptus* dans la partie inférieure de l'unité médiane. Plus haut dans l'unité médiane, une faune à conodontes représentative de l'intervalle entre les zones à *Lenodus variabilis* et à *Eoplacognathus suecicus* se rencontre juste au-dessus de la Zone à *Paraglossograptus tentaculatus* et avec des graptolites de la Zone à *Pseudoclimacograptus decoratus*. Dans l'unité de calcaire, des faunes contenant le conodonte *Phragmodus flexuosus* se rencontrent au-dessus des graptolites de la Zone à *P. decoratus* et sous ceux de la Zone à «*Glyptograptus*» *euglyphus*. *Phragmodus flexuosus* apparaît pour la première fois dans la Zone à *Cahabognathus friendsvillensis*. La meilleure corrélation directe avec la séquence de zones à graptolites se trouve près du sommet du membre inférieur dans la coupe de Judge Peak, dans la partie ouest du rentrant de White River, où les conodontes de la Zone à *Pygodus serra* sont associés à des graptolites qui indiquent une Zone à «*G.*» *euglyphus* tardive.

INTRODUCTION

The graptolite faunas of the Glenogle Shales (Burling, 1921) have been known for more than a century but their stratigraphic setting has been uncertain. The present contribution describes newly discovered stratigraphic sections, outlines the stratigraphy and depositional environments of the Glenogle Formation, puts forward a biostratigraphic synthesis of the graptolite faunas, and relates this zonation to North American zonations provided by conodonts and shelly fossils and to other graptolitic sequences throughout the world.

In Ordovician time, the site of the southern Rocky Mountains lay near the western margin of the North American craton (Fig. 1, 2; Cecile and Norford, 1993). Predominantly carbonate rocks of the Bow Platform extended westward to the Kicking Horse Rim (Aitken, 1972; B-C in Fig. 1 shows its approximate location during Glenogle time). Beyond lay the deeper water of the White River Trough, which itself was bounded westward by the Purcell Platform that was a land area or a shallow platform during much of the Ordovician.

During the Franconian and Trempealeauan (both Late Cambrian), Tremadoc, and early Arenig, the thick McKay Group of carbonates, shales and argillaceous carbonates accumulated in the trough in an extensive mid-slope environment of low gradient and merged eastward with platform carbonates of the Bow Platform (Mott, 1989; Mott et al., 1996; Cecile and Norford, 1993). Local deepening began in the early Arenig with the deposition of shale of the Glenogle Formation commencing in the northwest (Brisco Range) while McKay Group sedimentation continued elsewhere in the trough. Sea level rose abruptly in mid-Arenig time (*Didymograptus bifidus* Zone), and facies changed from McKay to Glenogle sediments throughout the rest of the trough. Similarly, on the Bow Platform to the east, the Outram Formation replaced the Survey Peak Formation of shallower depositional environment. The slopes at both the eastern and the western margins of the White River Trough were sufficiently steep for shelf sediments to slump down and be redeposited in deeper parts of the trough (Fig. 3). From the Bow Platform, extensive tongues of quartz sand and silt of the Tipperary Quartzite extended westward beyond Akutlak Creek. Near Pedley Pass in the central Stanford Range, detailed mapping of debris flows (Fig. 3) within the *Paraglossograptus tentaculatus* Zone of the Glenogle Formation by Gerard C. Bond (pers. comm., 1987) shows thickening and coarsening westward and indicates a western source such as the Purcell Platform. Clasts within these debris flows indicate the presence of shallow-water Whiterockian carbonate deposited on the Purcell Platform developed on the Purcell Arch, a structural feature active during Early Paleozoic time.

Deposition of dark grey shale and argillaceous limestone of the Glenogle continued until late Llanvirn time when quartz silt flooded into all parts of the trough. This episode presumably reflected shallowing that is documented on the adjacent Bow Platform by uplift, erosion and karstification of the open-marine Skoki Formation and by deposition of the overlying restricted-marine Owen Creek Formation. In the Beaverfoot, Brisco and Stanford ranges, the Upper Member of the Glenogle consists of pale orange-brown and light brown weathering siltstone and shale with abundant quartz silt. Carbonate dominates near the Bow Platform but similarly contains abundant quartz silt. Most of the record of Caradoc time is missing because of erosion prior to deposition of the Mount Wilson and Beaverfoot formations (both Ashgill), and in places the Beaverfoot Formation rests directly on Lower Ordovician, Cambrian and Precambrian rocks (Fig. 2). The White River Trough had disappeared by Ashgill time and shallow-water carbonates were present throughout the southern Rocky Mountains with the outboard edge of the cratonic carbonate platform at the Purcell Platform or further west.

Graptolites were first reported from Western Canada in 1887 by McConnell (also *see* Lapworth, 1887) from rocks, now known as the Glenogle Formation, along the Kicking Horse River (Fig. 1-E). The building of the Canadian Pacific Railway along the river provided easy access, and the diversity of the faunas encouraged sampling and study by many scientists. Soon the Glenogle Formation graptolites became known internationally, although the stratigraphic sequence remained obscure. The geological terrain is structurally complex and the Glenogle Formation is one of the least competent and thus one of the most internally deformed rock units. Many outcrops are faulted and sheared, especially in the major valleys of the Kicking Horse River and of Sinclair Creek (Fig. 1-E, J), which are where most of the early studies were conducted. During the past thirty years, comprehensive geological mapping of the Rocky Mountains has identified reliable stratigraphic sections of the Glenogle Formation, although faults and folds distort thicknesses within many of the sections.

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G.B. Leech and J.A. Mott kindly provided some of the stratigraphic data used in this report. R.C. Frey, E.L. Yochelson, M.J. Copeland, and J.K. Rigby, respectively, studied cephalopods, gastropods, ostracodes, and sponges from several collections. G.C. Bond made information available from his ongoing studies of the sedimentation and compaction history of the Glenogle Formation in the Stanford Range. A.D. McCracken, M.P. Cecile, R.A. Cooper, R.J. Ross, Jr., and S.H. Williams critically read early drafts and suggested vital improvements.

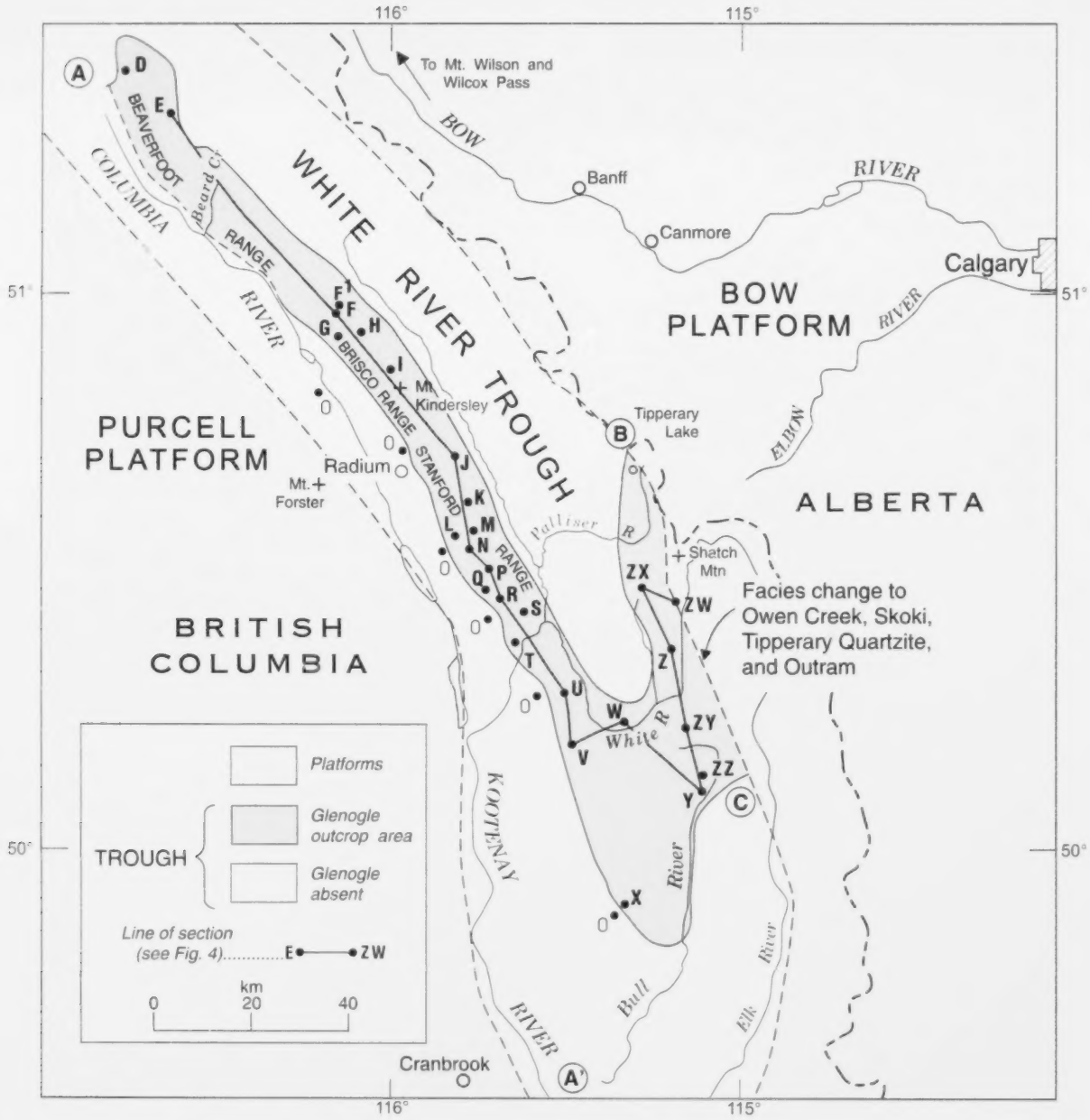


Figure 1. *Regional paleogeography, distribution, and location of stratigraphic sections of the Glenogle Formation. A-A' is the site of the Rocky Mountain Trench, A-B is a zero-edge of the Glenogle resulting from Cenozoic and more recent erosion; A-C is a zero-edge of the Glenogle resulting from erosion during Late Ordovician to Devonian time; B-C is the site of the Kicking Horse Rim and of facies change of the Glenogle into stratigraphic units of the Bow Platform.*

LITHOSTRATIGRAPHY OF THE GLENOGLE FORMATION

Important stratigraphic sections

The present-day distribution of the Glenogle Formation is entirely east of the Columbia River and extends from just north of Moberly Peak (Fig. 1-D) to the Top of the World area in the south and eastward to the Kicking Horse Rim (Fig. 1, Table 1). The type area is within the Beaverfoot Range (Fig. 1, 4-E) where stratigraphic thicknesses are uncertain. However Allan (1912, 1913, 1914), suggested a thickness of 520 m. The Glenogle Shales of Burling (1921, 1922), later were recognized to consist of a lower part made

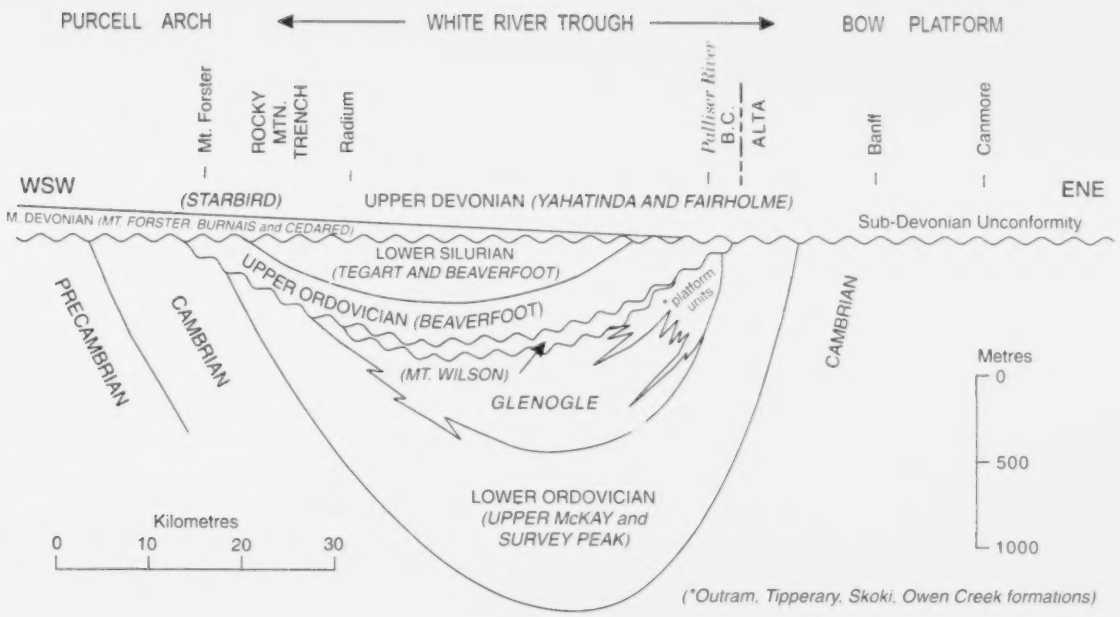


Figure 2. *Schematic cross-section, White River Trough.*

Table 1
Stratigraphic sections of the Glenogle Formation located in Figure 1 (* indicates faulted or folded section)

Letter in Figure 1	Name of stratigraphic section	Thickness m	Source of measurement
D	Moberly Peak	213+	Larson and Jackson (1967)
E	Kicking Horse River (Glenogle Halt)	*520+or-	Allan (1914)
F	Diana Lake	547	this study
F'	Judge Peak	*656	this study
G	"3 to 4 miles west of summit of Brisco Range"	30	Evans (1933)
H	"summit of Brisco Range"	350-400	Evans (1933)
I	Luxor Pass	457	Henderson (1954) and North and Henderson (1954)
J	Mount Sinclair	504+	Walcott (1924) and Henderson (1954)
K	Unnamed creek, eastern Stanford Range	360	Leech (1954, 1958) and pers. comm.
L	Near Redwall Fault	*183	Henderson (1954 and North and Henderson (1954)
M	Near Stanford Fault	305	Henderson (1954 and North and Henderson (1954)
N	North Fork Windermere Creek	61	Walker (1926)*
P	Head of Windermere Creek	*330+or-(659)	Walker (1926)* (includes revisions of original measurements)
Q	East of Mt. Tegart	137+or-	Walker (1926)*
R	Pedley Pass	40	this study
S	Nappe Mountain	91	Henderson (1954) and North and Henderson (1954)
T	Near Stanford Fault	*91	Henderson (1954) and North and Henderson (1954)
U	Moscow Creek	336	Leech (1954, 1958) and pers. comm.
V	White Knight Mountain	138	Leech (1954, 1958) and pers. comm.
W	Akutlak Composite	851	this study
X	Top of the World	150+	Leech (1954, 1958)
Y	South of Harrison Creek	50	Mott (1989)
Z	North White River	590	this study
ZZ	North of Harrison Creek	170	Mott (1989)
ZY	Rock Canyon Creek	230	Mott (1989)
ZX	Near North White River headwaters	275	Mott (1989)
ZW	Russell Peak	Zero	Mott (1989)

up of shale with interbedded mudstone and limestone, and an upper part with quartz silt as a conspicuous and dominant component. Some distance to the southeast, Walcott (1924) proposed the name Sinclair Formation for rocks in the northern Stanford Range (Fig. 1, 4-J) that he later recognized as part of the Glenogle (Walcott, 1928). Within the Beaverfoot Range, the isolated outcrops along the railway and the Kicking Horse River west of Glenogle Creek are discontinuous, structurally complex and difficult to correlate (Fig. 4-E). Burling specified a type section that later was recognized as consisting of the lowest reaches of Cable Creek together with the adjacent railway cutting to the east (Larson and Jackson, 1967, p. 498–499, 502, Section DJ-2-62, locs. 1, 2, 3, 3a, Pl. 2, figs. 1, 2), but a continuous composite section could not be compiled (*ibid.*, Fig. 3). About 50 km to the southeast, the same twofold division of the Glenogle Formation is present in a ridge section at Judge Peak (Fig. 1-F, 5) in the Brisco Range and the nearby creek section at Diana Lake. Two small chevron folds are present within the middle part of the Lower Member at Judge Peak (Fig. 6) but otherwise the Judge Peak Section and the adjacent Diana Lake Section appear to lack significant structural complication. A maximum thickness for the Glenogle Formation is 547 m at Diana Lake, of which about 215 m belong to the Upper Member and about 332 m to the Lower Member (441 m at Judge Peak but including repetitions by folds).

Walker (1926, p. 25–28) described an overturned, thick stratigraphic section near the headwaters of Windermere Creek within the central Stanford Range (Fig. 1, 4-P). This, the "great Windermere section" of Ruedemann (1947, p. 104), traditionally has been regarded as the reference section for the Glenogle and as best presenting the sequence of graptolite faunas within the formation. The stratigraphic section includes several, tight, isoclinal folds with substantial repetition of beds, and the exposures are not as complete today (particularly the upper part) as they were when studied by Walker because of more extensive vegetation.

Argillaceous limestone, limestone, and dolomite dominate in the eastern area of Glenogle Formation distribution. With such a diversity of rock types, the term Formation is more appropriate than Shales. The Akutlak Composite Section (Fig. 1, 4-W, 7, 8, and Appendix A) is about 160 km southeast of the type section along the Kicking Horse River and is here designated as the standard section of the Glenogle Formation with the type sections of its two members. The eastern flank of a broad syncline presents

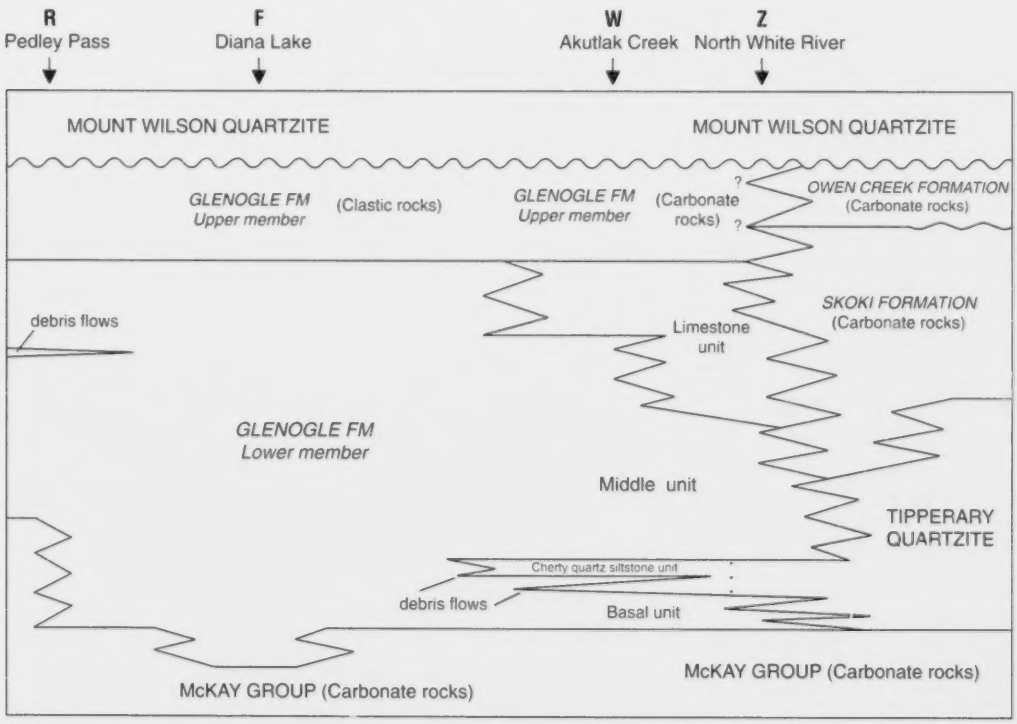


Figure 3. *Simplified regional relationships, upper Lower Ordovician and Middle Ordovician stratigraphic units. West and East refer to conceptual relationships at the time of sedimentation, not to present-day orientations.*

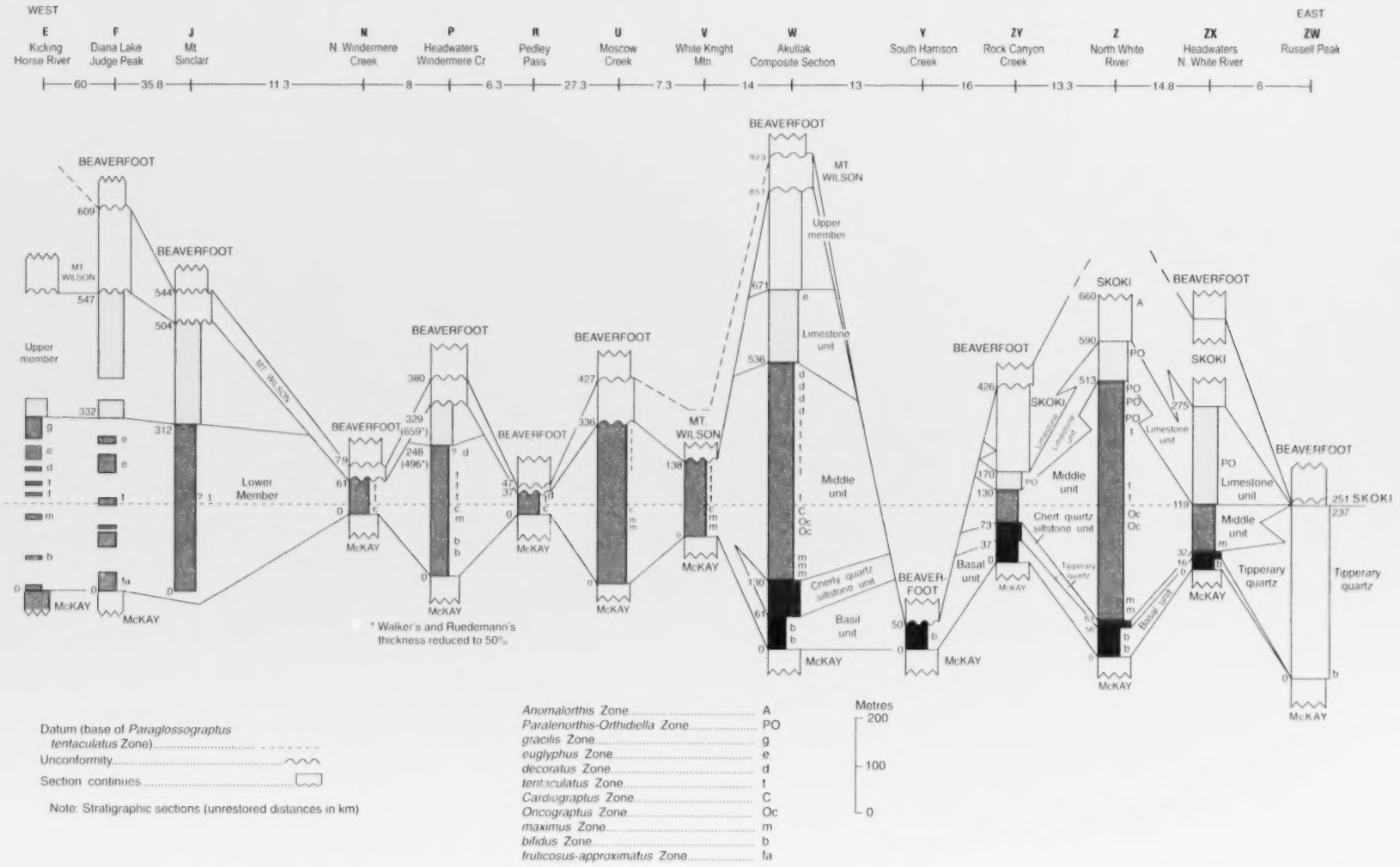


Figure 4. *Correlation of the more important stratigraphic sections of the Glenogle Formation; line of sections shown in Figure 1.*

Figure 5. *Judge Peak Section of the Glenogle Formation, view from west, Mount Wilson Quartzite forms peak, ribs of McKay Group are the lowermost outcrops (GSC photo no. 4344-11).*

Figure 6. *Judge Peak Section, chevron folds present within the Lower Member; uppermost beds of McKay Group in foreground (GSC photo no. 4344-2).*

excellent stratigraphic sections with complete exposure along the crests of steep ridges (Cover photograph and Fig. 9–13). Below these ridges, much of the formation is well exposed in a road cut (Fig. 14–16) beside the White River. The deep-water depositional environment was relatively close to the adjacent Bow Platform, and the Glenogle contains much more carbonate here than in localities farther west and northwest (Fig. 4). Some 15 km northeast of the Akutlak Section, the North White River Section (Fig. 1-Z, 4-Z) and the Headwaters of North White River Section (Fig. 1, 4-ZX, 17, and Appendix B) are located almost at the edge of the carbonate shelf and represent transitions between the depositional environments of the Bow Platform and those of the White River Trough (Fig. 3, 4). Carbonate dominates at the Headwaters of the North White River Section. Farther east (near Russell Peak, Fig. 1-ZW, 4-ZW) the Glenogle is totally absent except as partings within the Tipperary Quartzite, one of which has yielded graptolites of the *Didymograptus bifidus* Zone near the base of the formation.

Lithologies and members

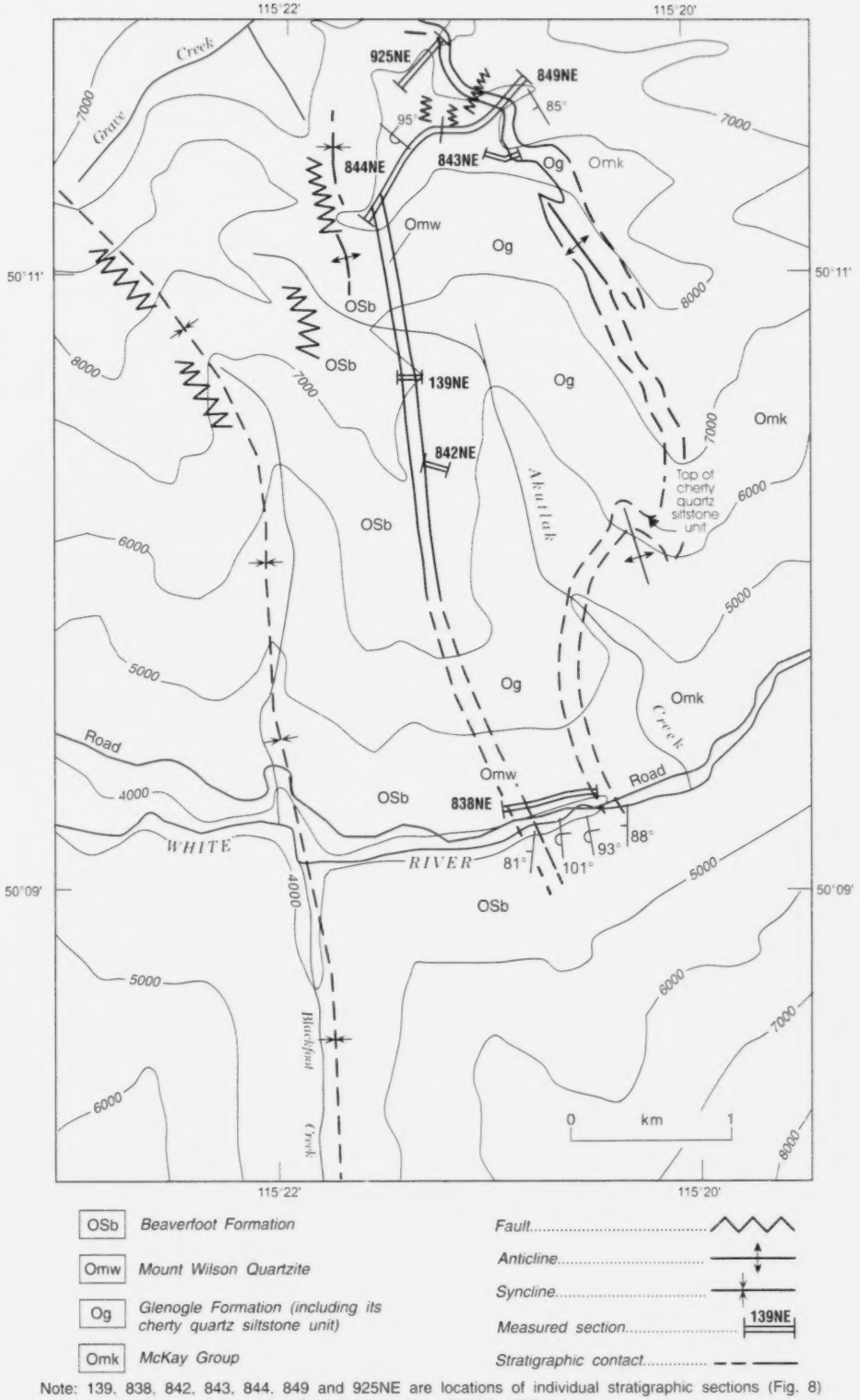
The Glenogle Formation is 851 m thick in the Akutlak Composite Section (Fig. 7, 8) with apparently conformable contact with the underlying McKay Group and with erosional disconformity beneath the overlying Mount Wilson Quartzite. Small faults are present and thus the total thickness may be inexact. An Upper Member and a Lower Member (here divided into four informal units) can be recognized in the section:

Upper Member (quartzose carbonate)	180 m
Lower Member	671 m
limestone unit	135 m
middle unit (argillaceous limestone and limy shale)	405.5 m
cherty quartz siltstone unit	69.5 m
basal unit (mudrock with quartz-silt laminae)	61 m

The units of the Lower Member can be mapped in the eastern outcrops of the Glenogle but lose their definition westward, away from the influence of the Bow Platform as the source of most of the components of carbonate and quartz silt. In the west, a two-part division of the Glenogle Formation is appropriate: the Lower Member is equivalent to all four lower units at the Akutlak Section and consists of mostly limy, dark grey shale, and argillaceous and shaly limestones with minor limestone beds; the Upper Member is equivalent to the Upper Member at the Akutlak Section but here consists of quartz siltstone, sandstone and rare shale with a minor carbonate component. At Diana Lake the two members are about 332 m and 215 m thick, respectively.

The basal unit forms a recessive interval above the McKay Group (Cover photograph, Fig. 10). Most of its mudstone and shale is noncalcareous, and cleavage is seldom developed. Thin laminae of fine quartz silt (Fig. 18) are so abundant that lichens are prominent on weathered outcrops. Graptolites are extremely rare. The unit is distinct east of White Knight Mountain (Fig. 1-V) but loses much of its quartz silt content westward.

The cherty quartz siltstone unit represents substantial incursions of quartz silt and sand into the depositional environment. The siltstone and sandstone are interbedded with siliceous and dolomitic mudstone and shale (Fig. 19–21). At the Akutlak Composite Section, near Harrison Creek



Note: 139, 838, 842, 843, 844, 849 and 925NE are locations of individual stratigraphic sections (Fig. 8)
Contour interval is 1000 ft. (305 m)

Figure 7. *Locality map showing the stratigraphic sections comprising the Akutlak Composite Section.*

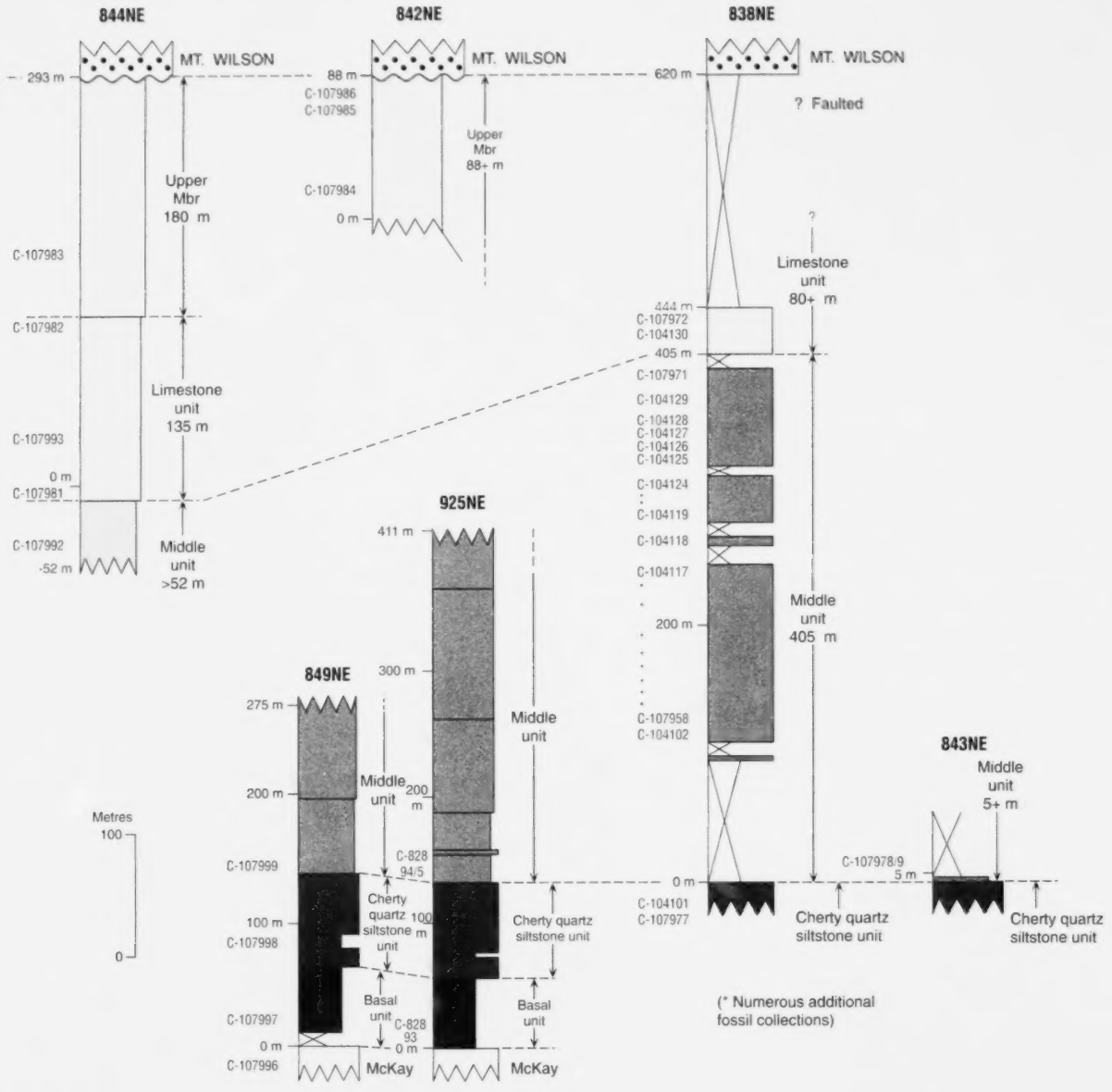


Figure 8. *Correlation diagram of stratigraphic sections comprising the Akutlak Composite Section.*

(Fig. 1-Y and ZZ) and elsewhere in the eastern area of the Glenogle Formation, the unit outcrops as upper and lower resistant ribs, dominantly of siltstone and sandstone, and an intervening midpart that is mostly shale and mudstone (Cover photograph, Fig. 10). The cherty quartz siltstone unit is the basinward equivalent of a tongue of Tipperary Quartzite, present within the Glenogle Formation at the North White River Section. The abrupt tops of these two units are considered to be synchronous in the eastern part of the White River Trough. The unit does not extend far westward of the Akutlak Composite Section and where it is absent, separation of the basal unit from the middle unit is based on carbonate being an important constituent in the middle unit.

The argillaceous limestone of the middle unit at the Akutlak Composite Section is well cleaved (Fig. 15, 16), mostly at various angles to the bedding. Fresh surfaces are drab and uniformly dark grey, but weathered outcrops are flaggy and yellowish grey, dull grey, light olive-grey, and pale yellowish brown. Less argillaceous limestone beds weather blocky and platy; some have sole markings on their

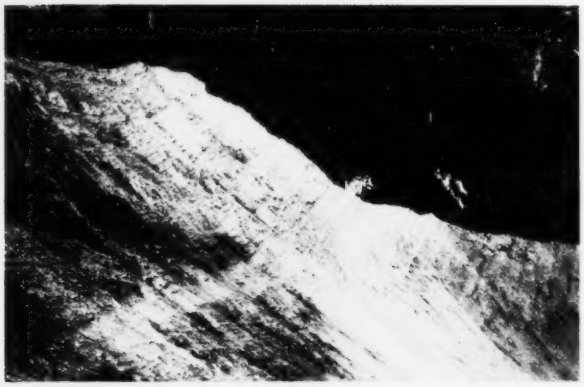


Figure 9. *Akutlak Composite Section, ridge-crest, grey outcrops of middle unit of Lower Member, Section 849 NE (GSC photo no. 3354-23).*

Figure 10. *Akutlak Composite Section, ridge-crest outcrops of Lower Member, Section 849 NE. (continues from Fig. 9). Cliffs of vertical McKay Group at extreme right, followed upsection to left by recessive basal unit, resistant cherty quartz siltstone unit (69.5 m thick) and recessive lower part of middle unit (GSC photo no. 3354-16).*

Figure 11. *Akutlak Composite Section, stripes of weathered greyish orange and grey outcrops of middle unit of Lower Member; limestone unit at left; Section 844 NE (GSC photo no. 3354-18).*

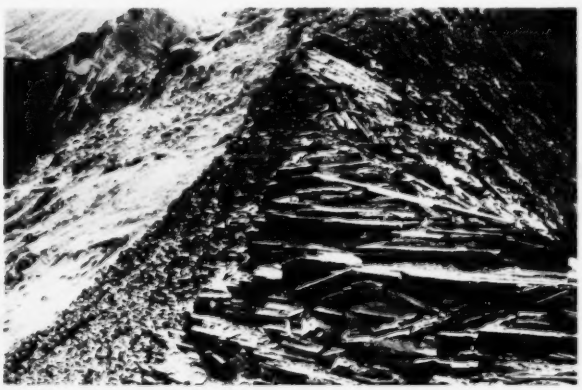


Figure 12. *Akutlak Composite Section, ridge-crest outcrops of platy limestone of limestone unit of Lower Member (1.5 metre staff provides scale); Section 844 NE, 23 m above base of unit (559 m above base of Formation) (GSC photo no. 3354-22).*

basal surfaces, indicating deposition by turbidity currents; a few have oolitic components (Fig. 22). Quartz silt is a minor constituent of some of these beds (Fig. 23–25), which therefore are lichen covered when well weathered. Limy shale is prominent as interbeds throughout the middle unit and at some levels forms a substantial component (Fig. 17). Thin chert beds are present in the basal beds and large limestone concretions are prominent near the top of the unit.

The limestone unit is characterized by thin beds of calcilutite (1–25 cm thick) that weather platy and blocky and, light grey, dull grey, light olive-grey and yellowish grey (Fig. 12, 26, 27). Limy shale interbeds are present throughout as minor components; quartz silt laminae occur in the upper beds of the unit. The limestone unit cannot be recognized in the western part of the White River Trough. In part this may be due to facies change and loss of carbonate westward, but in many sections the Mount Wilson Quartzite rests unconformably on horizons lower in the Glenogle. Eastward, the unit is nodular, mottled and dolomitic in the North White River region; these rocks previously were assigned to the Outram Formation (Norford, 1969; Norford and Ross, 1978).

The carbonate of the Upper Member at the Akutlak Composite Section consists of well bedded (1–100 cm

Figure 13. *Akutlak Composite Section, ridge-crest outcrops of resistant dolomites of Upper Member; Section 844 NE (GSC photo no. 3354-20).*

Figure 14. *Akutlak Composite Section, roadside outcrops of middle unit of Lower Member, Section 838 NE (GSC photo no. 3354-17).*

Figure 15. *Akutlak Composite Section, fresh roadside exposures of middle unit of Lower Member; Section 838 NE, prominent bedding plane is at 258.8 m. Cleavage parallels bedding; upsection is to left (GSC photo no. 3354-25).*

thick), very finely crystalline dolomite and limy dolomite within which quartz silt and fine quartz sand are pervasive constituents (Fig. 13, 28). Fresh surfaces are dark brownish grey and dark grey; weathered outcrops are brownish grey, pale brown, greyish orange and yellowish brown. Laminae of quartz silt and sand are present. Chert layers occur locally and dispersed blebs of silica are prominent in the upper third of the member. Shale is absent at the Akutlak Section.

The Upper Member in the central and western parts of the White River Trough is very different. Laminated quartz siltstone dominates, so the Upper Member generally weathers pale orange-brown and is far less recessive than the underlying Lower Member (Fig. 5, 29, 30). Some quartz silt also is present high within the Lower Member (Fig. 31). Platy limestone and limy shale are common in the lower 65 m but very rare at higher stratigraphic levels. Flute casts

Figure 16. *Akutlak Composite Section, fresh roadside exposures of middle unit of Lower Member; Section 838 NE. Cleavage is oblique to the bedding; upsection is to left (GSC photo no. 3354-19).*

and other sole marks were developed on the bases of some quartz siltstone beds (Fig. 32). The Upper Member's distribution is controlled by the downcutting of the sub-Mount Wilson unconformity, so it is missing from the western parts of the Stanford, Brisco and Beaverfoot ranges but present in many of their eastern parts (Fig. 3, 4). Burrows and feeding trails are prominent at Diana Lake (Fig. 33), Judge Peak, and Mount Sinclair but shelly fossils are very rare except as detrital fragments. The Upper Member is about 215 m thick at Diana Lake and may be more at Judge Peak. At Mount Sinclair some 192 m of the beds reported by Walcott (1924, p. 14, units 1a–d of his Sinclair Formation) represent the member. Similarly, at the Head of Windermere Creek Section, 163 m of Walker's succession (1926, p. 25) belong to the Upper Member. These thicknesses are not very accurate and the upper limit of the Upper Member is an unconformity; however, they are comparable to the thickness of 180 m at the Akutlak Section and allow the suggestion that the Upper Member was deposited as a siliceous blanket in the White River Trough but dominantly as carbonate in the east and as siltstone, sandstone and shale in the west.

The question of the source of the extensive volumes of quartz silt within the Upper Member remains to be resolved. To the east, the Owen Creek Formation of the Bow Platform (Fig. 1) documents part of the same interval. It represents a shallow, restricted-marine environment and is bounded by unconformities. Quartz silt and very fine-grained sand are common constitutents, and discrete, well rounded quartz sand grains are present in the upper beds (Norford, 1969, p. 55). Aeolian transport has been suggested for

Figure 17. *North White River Section, view from north-northeast, ridge-crest exposures of limestone unit of Lower Member (at peak and below; downsection is to right), middle unit, thin ledge of Tipperary Quartzite above recessive basal unit and resistant top beds of McKay Group. Beds at peak are 437 m above the base of the Glenogle (GSC photo no. 2733-1).*

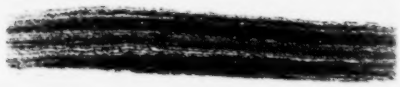


Figure 18. *Mudstone with layers of quartz silt, basal unit of Lower Member, Akutlak Composite Section; 30 m; 849 NE; x2 (GSC photo no. 3354-1).*

Figure 19. *Quartz siltstone with argillaceous layering, cherty quartz siltstone unit of Lower Member, top bed, Akutlak CompositeSection; 130.5 m; 838 NE; x2 (GSC photo no. 3354-5).*

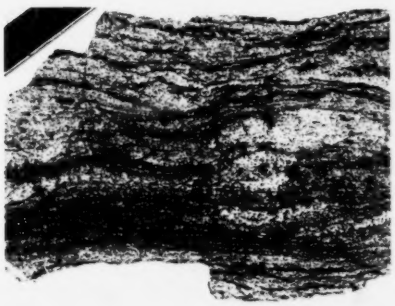


Figure 20. *Quartz siltstone with argillaceous layering, cherty quartz siltstone unit, Akutlak Composite Section; 85 m and 63 m; 849 NE; x2 (GSC photo no. 3354-3).*

contemporary quartz sands in the western United States (Ross et al., 1989). The craton east of Bow Platform and parts of the platform itself doubtless were land (without any cover of vegetation in Middle Ordovician time) and a likely source. The Tipperary Quartzite was an earlier accumulation of quartz sand that itself would have been part of the land surface locally and eroded during parts of the time represented by the Upper Member. An eastern source can certainly be demonstrated for the cherty quartz siltstone unit of the Lower Member, and most probably the Upper Member at Akutlak Creek represents carbonate and quartz silt transported from the Bow Platform to the east, mostly by water but also by wind, which would explain the presence of discrete grains of well rounded quartz sand in some beds. For the Upper Member in the Western Ranges, transport of quartz silt and sand from the Bow Platform may have been through submarine canyons and fans, as has been suggested for siltstone and sandstone of the Vinini Formation in Nevada (Finney and Perry, 1991) and of the Vuelta de Las Tolas member of the Suri Formation in northwestern Argentina (Mángano and Buatois, 1997). However, the possibility exists of substantial volumes of quartz silt being blown that far west from the craton and its fringing Bow Platform to be deposited in the relatively deep and quiet environment that lacked benthic faunas. A western source, the exposed Purcell Arch (Fig. 1), is also possible. Its land would have included outcrops of Precambrian clastic rocks and it was probably fringed by a carbonate shelf (Purcell Platform, as in early Whiterockian time) that provided the rare shell detritus found in the Diana Lake Section. Transport could have been by water or by wind, with final sedimentation as distal turbidites or tempestites. A third possibility for a source area is the Peace River Arch, far to the northwest, with transport by currents along the axis of the White River Trough; a similar model has been suggested for the Mount Wilson Quartzite (Ketner, 1968).

Formational contacts

The McKay-Glenogle contact appears to be gradational at some localities, abrupt at others. The oldest known Glenogle strata (*Pendeograptus fruticosus-Tetragraptus approximatus* Zone) are at the Diana Lake Section, where the gradational contact is well exposed by a waterfall on Pinnacle Creek (Fig. 34). The uppermost McKay beds consist of interbedded thin limestone beds and slaty shale. The boundary is selected where shale exceeds limestone that continues through the basal few metres of the Glenogle, but becomes lenticular and concretionary upward. In the nearby Judge Peak Section, the contact is more abrupt, and 15 m of basal Glenogle beds are followed by 20 m of McKay-like limestone below the main development of the Glenogle Formation (Fig. 6). Throughout the eastern part of the White River Trough the McKay-Glenogle contact is younger than

Figure 21. *Quartz siltstone with argillaceous layering, cherty quartz siltstone unit, Akutlak Composite Section; 85 m and 63 m; 849 NE; x2 (GSC photo no. 3354-12).*

Figure 22. *Ooilite grainstone, including large clast, middle unit of Lower Member, Akutlak Composite Section; 259 m; 849 NE; x2 (GSC photo no. 3354-8).*

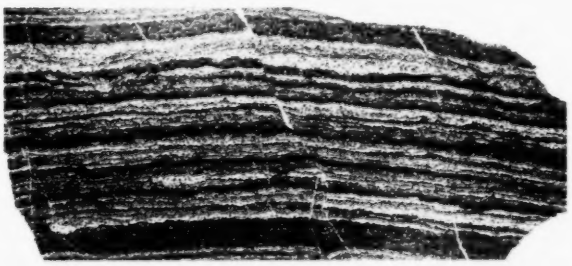


Figure 23. *Limy mudstone with minor quartz silt, middle unit of Lower Member, Akutlak Composite Section; 160.5 m; 849 NE; x2 (GSC photo no. 3354-10).*

Figure 24. *Argillaceous limestone, middle unit of Lower Member, Akutlak Composite Section; 190.5 m; 849 NE; x2 (GSC photo no. 3354-6).*

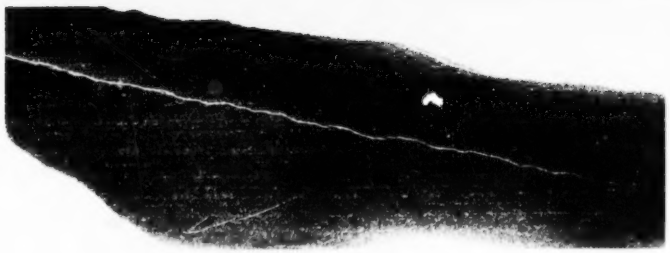


Figure 25. *Laminated limestone with quartz silt content, middle unit of Lower Member, Akutlak Composite Section; 210 m; 849 NE; x2 (GSC photo no. 3354-7).*

Figure 27. *Platy limestone (calcilutite with rare quartz silt), limestone unit of Lower Member, Akutlak Composite Section; 585.25 m; 844 NE; x2 (GSC photo no. 3354-2).*

Figure 26. *Akutlak Composite Section, folding in limestone unit of Lower Member (hammer provides scale); riverside outcrops of Section 838 NE (GSC photo no. 3354-24).*

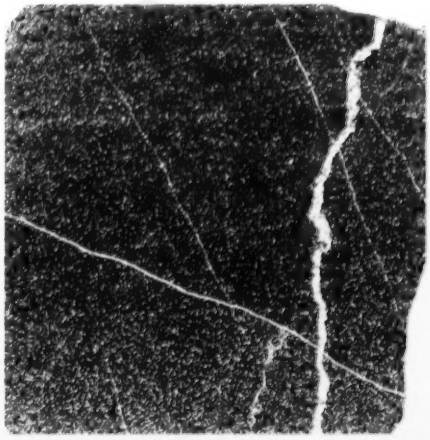


Figure 28. *Dolomite with abundant quartz silt, Upper Member, Akutlak Composite Section; 37 m below top, 842 NE; x2 (GSC photo no. 3354-4).*

Figure 29. *Diana Lake Section, top part, greyish orange and light brown weathering siltstone beds of Upper Member below cliffs of Mount Wilson Quartzite (GSC photo no. 3354-13).*

Figure 30. *Ridge east of Pinnacle Creek and a couple of kilometres southeast of Judge Peak Section, ledges of Upper Member outcrop above recessive Lower Member and below cliffs of Mount Wilson Quartzite (about 153 m thick) and Beaverfoot Formation (BSN photo no. 10-8-62).*

Figure 31. *Shale with sparse quartz silt and layers of lime silt, upper part of Lower Member, roadside exposures, Kicking Horse River; x2 (GSC photo no. 3354-11).*

Figure 32. *Judge Peak Section, sole markings on bases of quartz siltstone beds, basal part of Upper Member (1.5 m staff provides scale) (GSC photo no. 4344-1).*

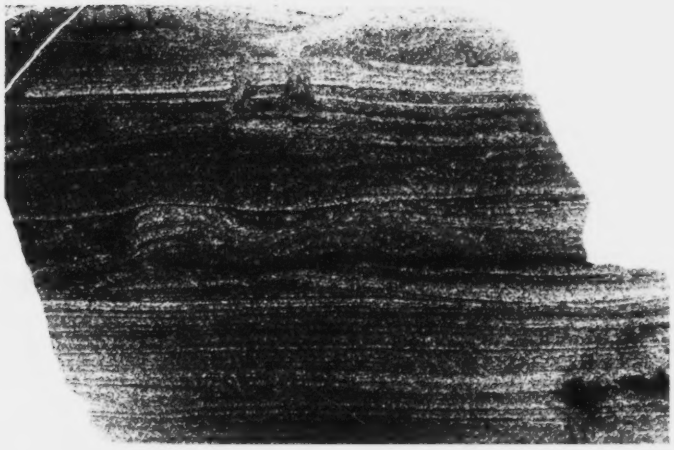


Figure 33. *Quartz siltstone with argillaceous lamination, Diana Lake Section, 30 m below top of Upper Member; x2. Burrows (upper centre) penetrate the laminae which locally show truncation. Pyrite crystals in lower right (GSC photo no. 3354-9).*

at Diana Lake and within the *Didymograptus bifidus* Zone (perhaps corresponding to the 35 m level above the base of the Glenogle at Judge Peak). The contact is abrupt at the Akutlak Creek Composite Section (Fig. 10) and at the North White River Section (Fig. 17); at the latter, the contact is picked at the base of argillaceous quartz siltstone beds conformably overlying nodular and laminated dolomite. The Pedley Pass region is anomalous in that the *Cardiograptus* Zone is present just 2 m above the McKay, requiring either a very condensed sequence to account for the *Didymograptus bifidus*, *Isograptus victoriae maximus*, and *Oncograptus* zones, or McKay Group deposition here persisting into the times of most of these zones.

The Glenogle-Mount Wilson contact is an abrupt unconformity with angular relationships locally near the North White River. Erosion surfaces are evident at Diana Lake and particularly in the Akutlak Composite Section where there are 2 m of local relief, and karst fissures are filled by Mount Wilson Quartzite down as much as 70 m into the Glenogle Formation. Regionally the unconformity cuts down to various levels within the Glenogle, cutting out the Upper Member and some of the units of the Lower Member. However, at Diana Lake and Judge Peak, the uppermost beds of the Upper Member consist of quartz siltstone and sandstone, some with siliceous cement, and the contact with the clean quartz sandstone of the Mount Wilson Quartzite is paraconformable. The Beaverfoot Formation regionally oversteps the Mount Wilson Quartzite to rest on older rocks, but only in the Top of the World area (Leech, 1958, p. 15) does the Beaverfoot rest directly on the Glenogle Formation.

The contact between the Lower Member and the Upper Member is gradational. In the east, in the Akutlak Creek Composite Section, the contact is picked at a change from limestone to dolomite that contains quartz silt and sand. In the northwest, at Judge Peak, the contact is picked above platy argillaceous limestone and limy shale at the base of a prominent set of quartz siltstone beds (5 m total). However, above these beds, argillaceous limestone and limy shale are

Figure 34. *Diana Lake Section, gradational basal contact of dark grey Lower Member of Glenogle Formation with grey McKay Group (to right) at waterfall in Pinnacle Creek; bedding vertical, figure (Jin Jisuo) on uppermost McKay beds provides scale (GSC photo no. 3354-14).*

much more common than the siltstone and continue to be common in the overlying 60 m of the Upper Member.

GRAPTOLITE FAUNAS AND BIOSTRATIGRAPHY

Many scientists have reported graptolites from the Glenogle Formation and correlated the faunas according to a variety of zonal schemes (McConnell, 1887; Lapworth, 1887; Allan, 1914; Burling, 1921, 1922; Walcott, 1924; Clark, 1926; Walker, 1926; Evans, 1933; Ruedemann, 1947, and quoted within several of the previous publications; Henderson, 1954; Leech, 1954; Jackson, 1964; Larson and Jackson, 1967; Norford, 1969; McKee, Norford and Ross, 1972; Lenz and Jackson, 1986). Ruedemann described a number of taxa from the formation, including several new species (Appendix E provides the present generic and specific assignments of Ruedemann's taxa). The present study is based primarily on the distribution of taxa in the Akutlak Creek Composite and North White River sections, supplemented by data from other sections, especially from the outcrops beside the Kicking Horse River for the uppermost faunas. The study demonstrates that the sequence of graptolite faunas has close affinities to the Australasian sequence of the Pacific Faunal Province (see also Jackson, 1964; Larson and Jackson, 1967; Cooper, 1973, 1979; Barnes, Jackson and Norford, 1976; Barnes, Norford and Skevington, 1981; Cooper and Fortey, 1982; Lenz and Jackson, 1986; Williams, 1988; Williams and Stevens, 1988; Cooper and Lindholm, 1990; Cooper, Fortey and Lindholm, 1991; VandenBerg and Cooper, 1992) which can be applied to the Glenogle with only minor modifications (Fig. 35). Details are given of the zones documented from stratigraphic sections (Fig. 4) and of the stratigraphic occurrences of graptolite taxa in the Akutlak Composite and North White River sections (Fig. 36, 37). Figure 38 collates the stratigraphic ranges of graptolite taxa from Figures 36 and 37 and from a number of other localities. Figures 36 and 37 and Appendix D list the basic data of the taxa present in each collection.

The preservation of graptolites varies from mediocre to poor. Thermal maturities are high (Conodont Alteration Indices mostly 4 to 5) and, except in some limestone beds, cleavage is prevalent, mostly at medium to high angles to the bedding, making sampling difficult. In brown-grey calcareous mudstone, graptolites are preserved as black films; in weathered grey shale as greyish white films. They seem to be very rare within weathered outcrops on the crests of ridges. Some graptolites in argillaceous limestone and limestone are partly replaced by pyrite, and completely pyritized, fragmentary, three-dimensional specimens are known from one calcarenite bed at Judge Peak. However, the specimens lack periderms and appear to have been transported.

Bendigonian Stage

The Bendigonian zonation used today in Australia (VandenBerg and Cooper, 1992) follows the proposals of Harris and Thomas (1938) who defined the base by a burst of new forms including pendent tetragraptids, horizontal didymograptids and *Phyllograptus*. In Victoria, four zones are defined on the basis of occurrences of *Tetragraptus approximatus* and forms of *Pendeograptus fruticosus* with three or four stipes as shown below in descending order:

- Be4 Zone of *Pendeograptus fruticosus* (3-stiped forms only)
- Be3 Zone of *Pendeograptus fruticosus* (3- and 4-stiped)
- Be2 Zone of *Pendeograptus fruticosus* (4-stiped)
- Be1 Zone of *Pendeograptus fruticosus* with last survivors of *Tetragraptus approximatus*

Literature citations of zonal notations in Victoria are confusing, however the numbering used today (Fig. 35) stems from Harris and Thomas (1938) who changed zonal lettering on some of the Victorian stages and renumbered every zone in each stage from the oldest zone upward. In Newfoundland, the *Tetragraptus akzharensis* Zone of Williams and Stevens (1988) largely corresponds to Be1.

Pendograptus fruticosus-Tetragraptus approximatus Zone (Be1)

In the southern Rocky Mountains, the Bendigonian is represented by carbonate rocks of the McKay Group except in the area depicted in the northwestern part of Figure 1, where the Be1 Zone is documented at a single locality in the Diana Lake Section. There, the bed of Pinnacle Creek (Fig. 34) has yielded an assemblage of *Pendeograptus fruticosus*, *Tetragraptus approximatus*, *T. acclinans*, *Phyllograptus* sp., *Clonograptus* sp., *Didymograptus ensjoensis*, and *D. extensus*, from just above the base of the Glenogle Formation (Appendix D). This assemblage indicates early Bendigonian (Be1) of Victoria and is the oldest biostratigraphic horizon established in the formation. Glenogle rocks above these levels at Diana Lake and at Judge Peak may represent the later Bendigonian but graptolites have yet to be collected that document Be2 to Be4.

This early Bendigonian Zone may also be present low within the Headwaters of Windermere Creek Section (82–125 feet of Walker's measurement) where faunules that appear to underlie a Chewtonian fauna are dominated by horizontal species of *Tetragraptus* and extensiform *Didymograptus*. Another possible occurrence was described by Larson and Jackson (1967, p. 494; Walcott's location 21K) from a railway cutting beside the Kicking Horse River; the faunule was reported to include

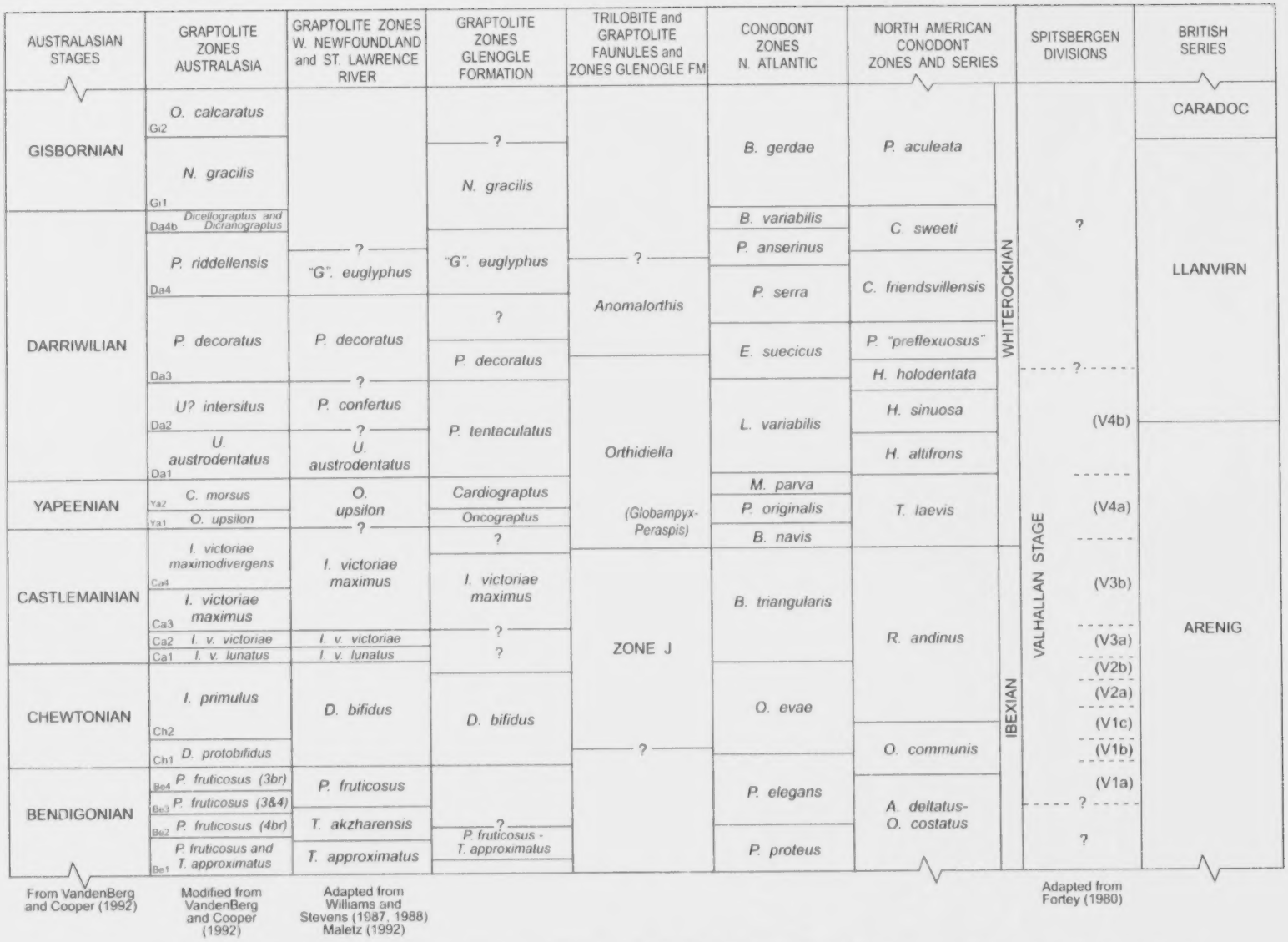


Figure 35. *Biostratigraphy of the Glenogle Formation and comparison with key successions in Australia, Newfoundland, and Spitsbergen.*

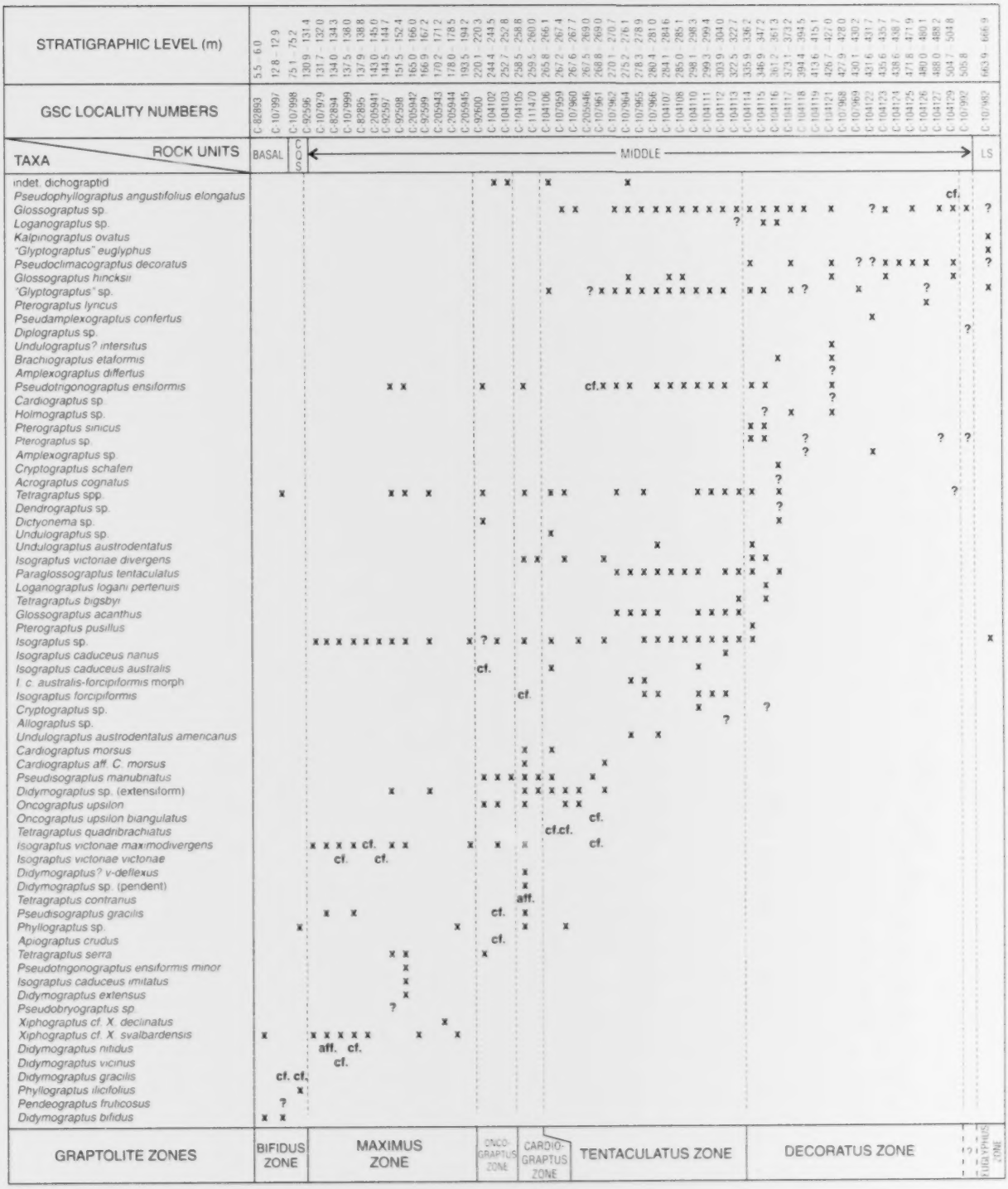


Figure 36. *Distribution of graptolite taxa, Akutlak Composite Section: CQS is the cherty quartz siltstone unit.*

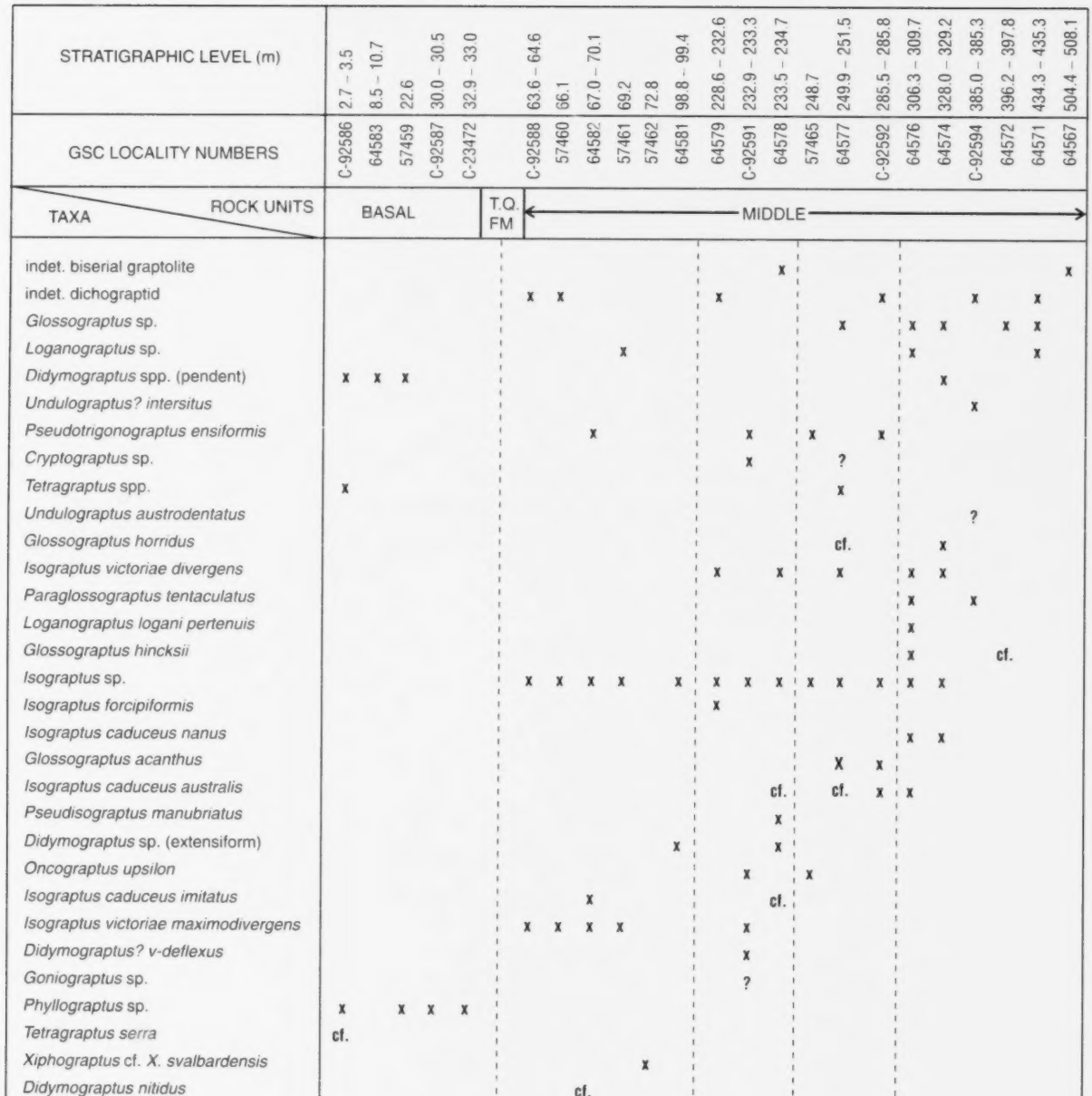


Figure 37. *Distribution of graptolite taxa, North White River Section; TQ is the Tipperary Quartzite.*

Taxa \ Graptolite zones	*fruticosus* Be1	*bifidus* Ch1-2	*maximus* Ca3-4	*Oncograptus* Ya1	*Cardiograptus* Ya2	*tentaculatus* Da1-2	*decoratus* Da3	*euglyphus* Da4	*gracilis* Gi1
Dicranograptus sp.									x
Dicellograptus forceps									x
Dicellograptus sextans									cf.
Dicellograptus smithi									cf.
Leptograptus sp.									x
Nemagraptus gracilis									cf.
Reteograptus geinitzianus									x
Thamnograptus capillaris									x
Protistograptus rectus									x
Parabrograptus tribrachiatus									x
Didymograptus sagitticaulis									x
Glossograptus hincksii bispinatus									x
Glossograptus ciliatus douglasi									x
Glossograptus whitfieldi									cf.
Hustedograptus teretiusculus								cf.	cf.
Dicellograptus geniculatus								cf.	
"Glyptograptus" euglyphus								x	
Cryptograptus tricornis								x	
Kalpinograptus ovatus								x	
Pseudoclimacograptus decoratus							x	cf.	
Glossograptus hincksii					x	x	x	cf.	
Amplexograptus differtus							?		
Pseudamplexograptus confertus							x		
Didymograptus serratulus							x		
Brachiograptus etaformis							x		
Pterograptus lyricus							x		
Pseudophyllograptus angustifolius elongatus							cf.		
Cryptograptus schaeferi					x	x	x		x
Undulograptus? intersitus						x	x		
Holmograptus nodosus						x			
Holmograptus spinosus							x		
Acrograptus cognatus						cf.	?		
Pseudotrigonograptus ensiformis			x	x	x	x	x		
Pterograptus sinicus							x		
Tetragraptus bigsbyi						x	x		
Loganograptus logani						x			
Loganograptus logani pertenuis						x	x		
Paraglossograptus tentaculatus						x	x		
Isograptus victoriae divergens				x	x	x	x		
Undulograptus austrodentatus austrodentatus						x	x		
Undulograptus austrodentatus americanus						x			
Pterograptus pusillus							x		
Pseudoclimacograptus nddellensis							x		
Bergstroemograptus crawfordi							x		
Pendeograptus pendens						x			
Didymograptus indentus						x			
Didymograptus lepidus						cf.			
Cryptograptus antennarius						?			
Cryptograptus inutilis					x				
Glossograptus horridus					?	x			
Glossograptus echinatus major						x			
Glossograptus echinatus					x	x			
Glossograptus acanthus					x	x			
Glyptograptus gladius						x			
Pseudobryograptus incertus						x			
Tetragraptus bigsbyi latus						x			
Tetragraptus serra		cf.	x	x	cf.	cf.			
Isograptus caduceus nanus						x			
Isograptus caduceus australis				cf.	x	x			
Isograptus forcipiformis-australis morph.						x			
Isograptus forcipiformis				x	cf.	x			
Apiograptus crudus				cf.	cf.				
Isograptus victoriae maximodivergens			x	x	x	cf.			
Cardiograptus morsus					x				
Cardiograptus aff. C. morsus					x				
Skiagraptus gnomonicus					x				
Tetragraptus amii					cf.				
Tetragraptus contrarius					aff.				
Tetragraptus quadribrachiatus					cf.				
Oncograptus upsilon				x	x				
Oncograptus upsilon biangulatus				x	cf.				
Pseudisograptus manubriatus				x	x				
Pseudisograptus hastatus			x						
Pseudisograptus gracilis			x	cf.	x				
Didymograptus? v-deflexus				x	x				
Didymograptus nitidus			cf.		cf.				
Isograptus victoriae victoriae			cf.	cf.	cf.				
Isograptus victoriae maximus			x						
Didymograptus extensus lineans			x						
Isograptus caduceus imitatus			x						
Tetragraptus amii				cf.	cf.				
Didymograptus vicinus			cf.						
Xiphograptus svalbardensis		cf.	cf.						
Xiphograptus declinatus			cf.						
Phyllograptus angustifolius angustifolius			x						
Phyllograptus walkeri			x						
Pseudotrigonograptus ensiformis minor			x						
Didymograptus bifidus		x							
Didymograptus gracilis		cf.							
Perissograptus pygmaeus		x							
Tetragraptus minutus		cf.							
Phyllograptus ilicifolius		x							
Phyllograptus typus		x							
Didymograptus extensus	x	cf.	x						
Pendeograptus fruticosus	x	?							
Tetragraptus acclinans	cf.								
Didymograptus vicinus	cf.								
Tetragraptus approximatus	x								
Didymograptus ensjoensis	x								

Figure 38. *Distribution of graptolite taxa, composite for the Glenogle Formation.*

Tetragraptus cf. *T. quadribrachiatus*, *P. fruticosus*?, and *Didymograptus extensus*?. In the eastern development of the Glenogle Formation, carbonate sediments of the McKay Group were deposited during Bendigonian time (Fig. 4).

Chewtonian Stage

The Chewtonian was introduced in Victoria to emphasize the importance of the incoming of "tuning-fork" didymograptids. Today's usage is that proposed by Thomas (1960) who restricted the stage to Ch1 and Ch2, making it equivalent to Harris's (1935) original "*Didymograptus proto-bifidus* Passage Beds". The older zone (Ch1) is defined by the occurrence of *Pendeograptus fruticosus* (3-stiped) in association with *D. bifidus*, whereas the younger zone Ch2 has *D. bifidus* with the enigmatic *Isograptus primulus* entering near the top of the stage.

Didymograptus bifidus Zone (Ch1)

Except for the locality near Diana Lake, the *Didymograptus bifidus* Zone is the oldest graptolite Zone documented in stratigraphic sections of the Glenogle Formation. In the Akutlak Composite Section (Fig. 36), *Didymograptus* (*Didymograptellus*) *bifidus* is known from the 5.5–6.0 m and 12.8–12.9 m levels (above the McKay Group), associated with *Pendeograptus fruticosus*?, *Didymograptus* cf. *D. gracilis*, and *Xiphograptus* cf. *X. svalbardensis*. The presence of *P. fruticosus*? indicates the lower part of the *bifidus* Zone as developed in Newfoundland (Williams and Stevens, 1988). The next 62 m of the basal unit of the Glenogle is virtually unfossiliferous but a collection at 75.1–75.2 m includes *Didymograptus* cf. *D. gracilis* and *Phyllograptus ilicifolius*, giving the *Didymograptus bifidus* Zone a thickness of at least 70 m. Biostratigraphically significant graptolites have not been found between 75.2 m and the lowest occurrence of *Isograptus victoria maximodivergens* at 130.9 m.

To the northeast, the zone is documented in the measured section north of North White River (Fig. 4-ZX), at levels 1–1.25 m and 11.25–11.5 m above the McKay Group; the combined assemblage is *Didymograptus* (*Didymograptellus*) *bifidus* and *Phyllograptus* sp. In the North White River section itself, the *Didymograptus bifidus* Zone is well documented at four levels through at least 30.3 m of the measured section (Appendix D, Fig. 34; Norford and Ross, 1978). The zonal assemblage comprises *D.* (*D.*) *bifidus*, *Phyllograptus typus*, *P.* sp., and *Tetragraptus* cf. *T. serra*. Leech collected the zone from two localities within an overturned stratigraphic section in the eastern Stanford Range (Fig. 1-K), at "2745 feet" and "2600 feet" (GSC localities 65732, 65731) where the assemblages included *Didymograptus bifidus*, *D.* cf. *D. extensus*, *Phyllograptus* sp., *Sigmagraptus* sp., *Tetragraptus* cf. *T. serra*, *T. serra?* and *Pendeograptus fruticosus?* Lastly, at Walker's (1926) Headwaters of Windermere Creek Section, his collections from his 275, 414, and 530 feet levels include the type specimens of *Didymograptus canadensis* and *D. columbianus* (both now considered as synonyms of *D. bifidus*) in association with *Phyllograptus ilicifolius*.

Stratigraphic thicknesses are exaggerated by deformation within that section [Walker's measurements (1926, p. 26–27) indicate that the *bifidus* Zone may be between 255 and 609 feet (78–186 m) thick; Fig. 4 reduces thicknesses by a token 50%].

Castlemainian Stage

Harris and Keble (1932) viewed this stage as the sequence of beds in which isograptids evolved to an "acmic stage" of development both in size and numbers. Later Harris (1933) schematically illustrated his ideas on the evolution of the *Isograptus "caduceus"* lineage, successively *primulus - lunata - victoriae - maximus - maximodivergens - divergens;* with *I. primulus* beginning within the late Chewtonian and *I. maximodivergens* and *I. divergens* persisting into the Darriwilian. Cooper (1973) reassigned *I. caduceus lunatus* and its descendants as subspecies of *I. victoriae*. Toward the end of the Castlemainian, the lineage possibly gave rise to manubriate isograptids such as *Meandrograptus* and *Pseudisograptus* (Cooper and Ni, 1986) while an ancestral branch developed a tendency toward a concrescent habit (*Oncograptus*, *Paracardiograptus* and *Cardiograptus*; Fortey and Cooper, 1986). Harris and Thomas (1938) considered the stage to have three zones (Ca1 to Ca3) but VandenBerg and Cooper (1992) modified the scheme by segregating the upper part of Ca3 as Ca4:

Ca4 *Isograptus victoriae maximodivergens*
Ca3 *Isograptus victoriae maximus*
Ca2 *Isograptus victoriae victoriae*
Ca1 *Isograptus victoriae lunatus*

However, Williams and Stevens (1988) stressed the morphological overlap between *I. v. maximus* and *I. v. maximodivergens*, and the present work uses an *I. v. maximus* Zone that encompasses both Ca3 and Ca4 of VandenBerg and Cooper.

Isograptus victoriae maximus Zone (Ca3 and Ca4)

The Castlemainian Stage has a minimum thickness of 63.3 m in the Akutlak Composite Section (Fig. 36) with a barren interval 55.7 m thick separating *Didymograptus bifidus* Zone assemblages from those of the Castlemainian. The Castlemainian does not lend itself to subdivision; indeed, the

Victorian zones Ca1 and Ca2 apparently are not represented by fossiliferous rocks throughout the White River Trough. It is conceivable that parts of these early Castlemainian zones are represented by unfossiliferous rocks of the Cherty Quartz Siltstone Unit and Tipperary Quartzite, but these two units were probably deposited very rapidly. Interestingly, a similar situation applies in Australia where Webby (1976, p. 243) noted that "Establishment of the base of the Castlemainian presents a problem because of the sparse fauna and lack of diagnostic forms".

In the Akutlak Composite Section, the *I. v. maximus* Zone is defined as the parts of the local range zones of *I. v. maximus* and *I. v. maximodivergens* below the first occurrence of *Oncograptus upsilon*, which marks the base of the Yapeenian. The Zone extends from 130.9 m to 194.2 m and the zonal assemblage consists of *Didymograptus gracilis, D. extensus, D.* cf. *D. nitidus, D.* cf. *D. vicinus, I. caduceus imitatus, Isograptus victoriae maximodivergens, I.* cf. *I. victoriae victoriae, Tetragraptus serra, Xiphograptus* cf. *X. declinatus* and *X.* cf. *X. svalbardensis. Pseudotrigonograptus ensiformis* commences in the upper part of the Zone.

In the North White River Section, the *I. v. maximus* Zone is represented in collections from 63.5 to 99.4 m giving a minimum zonal thickness of 36 m. Elsewhere, the zone is recorded in the eastern Stanford Range (Fig. 1-K, GSC loc. 65728), Moscow Creek (Fig. 1-U, GSC loc. 23928, 23931; Leech, 1954), White Knight Mountain (Fig. 1-W, GSC loc. 23937, 23929, 23935; Leech, 1954), in the Headwaters of Windermere Creek Section [at 734 and 780 ft. of Walker's (1926) measurements] and in the railway cuttings beside the Kicking Horse River.

Yapeenian Stage

In Victoria, Harris (1916) recognized the utility of *Oncograptus* and *Cardiograptus* as a basis for two zones between the Castlemainian and his Darriwilian. In his original description of *Cardiograptus morsus*, he stated (1924, p. 95):

> "It occurs with *Oncograptus*, but not in the lowest beds in which *Oncograptus* is found. It then survives *Oncograptus*. . . ."

This clearly implies that the ranges of these two taxa partly overlap and that *Oncograptus upsilon* uniquely characterizes a stratigraphic interval that is older than *Cardiograptus morsus*. In 1932, Harris and Keble proposed five zonal subdivisions of the then Darriwilian in which the lowest three zones were based on overlapping stratigraphic ranges. These were:

(D3) *Cardiograptus morsus* only
(D4) *Cardiograptus morsus* associated with *Oncograptus*
(D5) *Oncograptus* only

Later these zones were reassigned from the Darriwilian to the new Yapeenian Stage so that D5 became Ya1 and D3 and D4 constituted Ya2 (*sensu* Harris and Thomas, 1938). The assemblages of these two Yapeenian zones have the following important criteria according to the range charts of VandenBerg and Cooper (1992):

Cardiograptus morsus Zone (Ya2)

First appearances of *Cardiograptus morsus, Apiograptus crudus* and *Paracardiograptus* sp. with continuing taxa that include *Oncograptus upsilon, Isograptus caduceus australis* and *Skiagraptus gnomonicus*.

Oncograptus Zone (Ya1)

First appearances of *Oncograptus upsilon, Cryptograptus inutilis, Didymograptus v-deflexus, Isograptus caduceus australis, I. victoriae divergens, Pseudisograptus dumosus* Form B, *P. jiangxiensis, P. manubriatus, P. manubriatus tau* and *Skiagraptus gnomonicus*.

The Yapeenian is the main period of isograptid radiation, which started during late Castlemainian. However, the trend of increase in size that is seen in the *Isograptus victoriae* lineage during Ca1 to Ca3 time is reversed in the Yapeenian, with the transition from *I. v. maximodivergens* to the smaller *I. divergens*.

In the Akutlak Composite Section, the *I. v. maximus* Zone is separated from the overlying Yapeenian by a 26 m interval without any collections of graptolites; there is a similar barren interval of 129 m in the North White River Section. In the Akutlak Section, the base of the *Oncograptus* Zone is drawn at the entry of *Oncograptus upsilon* at 220.1–220.3 m, and the top of the Yapeenian is placed below the first appearance of *Paraglossograptus tentaculatus* at 270.1–270.7 m.

Oncograptus Zone (Ya1)

In the Akutlak Creek Composite Section (Fig. 36), the Yapeenian is 45.7 m thick and is divided into Ya1 and Ya2 on the basis of the ranges of *Oncograptus upsilon* and *Cardiograptus morsus*. The *Oncograptus* Zone is 38.4 m thick, with the base at the entry of *O. upsilon* at 220.1–220.3 m and the top at 258.5 m, the lowest occurrence of

Cardiograptus morsus. The zonal assemblage comprises the first appearences of *Oncograptus upsilon* and *Pseudisograptus manubriatus* and the continuing taxa *Diymograptus* cf. *D. gracilis*, *Isograptus victoriae maximodivergens*, *I.* cf. *I. caduceus australis* *Pseudotrigonograptus ensiformis* and *Tetragraptus serra*.

In the North White River Section (Fig. 37), the stratigraphic interval between 228.6 m and 234.7 m, within the carbonate-rich middle unit of the Lower Member, contains *Oncograptus upsilon*, *Diymograptus* cf. *D. gracilis*, *D.*? *v-deflexus*, *Isograptus* cf. *I. caduceus australis*, *I.* cf. *I. caduceus imitatus*, *I. victoriae divergens*, *I. forcipiformis*, *I. victoriae maximodivergens*, *Pseudisograptus manubriatus* and *Pseudotrigonograptus ensiformis*. The overlying *Cardiograptus* Zone has not been recognized unequivocally within the North White River Section, but 72.6 m of strata separate the highest documentation of the *Oncograptus* Zone from the lowest occurrence of the *Paraglossograptus tentaculatus* Zone at 306.3 m.

Cardiograptus Zone (Ya2)

In the Akutlak Composite Section (Fig. 36), the *Cardiograptus* Zone is 7.3 m thick and begins with the first appearance of *Cardiograptus morsus* at 258.5–258.8 m. Associated are *Cardiograptus* aff. *C. morsus*, *Didymograptus* sp. (declined), *D.* cf. *D. gracilis*, *Didymograptus*? *v-deflexus*, *Isograptus* cf. *I. forcipiformis*, *I. victoriae divergens*, *I. victoriae maximodivergens*, *Oncograptus upsilon*, *Phyllograptus* sp., *Pseudisograptus manubriatus*, *Pseudotrigonograptus ensiformis*, *Tetragraptus* cf. *T. approximatus* and *T.* aff. *T. contrarius*.

The *Cardiograptus* Zone is known from other localities. In the North Fork of Windermere Creek (Fig. 1-N), a short section of uncertain stratigraphic position within the formation documents 11 m of the *Cardiograptus* Zone below the *tentaculatus* Zone. *Cardiograptus morsus* and *Apiograptus* cf. *A. crudus* are present at the 2 and 9 m levels (Appendix D), respectively. Nearby, at the Headwaters of Windermere Creek Section, Walker collected graptolites that later became the type specimens of *Cardiograptus angustifolius* and *C. folium* (both herein considered as junior synonyms of *C. morsus*) from the 784 foot level (GSC loc. 7836; now positioned at 119.5 m in Fig. 4) of his measured section (1926, p. 26, 27). This horizon now is considered to be within the *Cardiograptus* Zone.

Within the Diana Lake Section (Appendices C, D) two collections probably represent the *Cardiograptus* Zone, with *C. morsus* continuing into the overlying *tentaculatus* Zone. At Pedley Pass (Fig. 1-R; Appendix D), a collection just 2 m above the base of the Glenogle Formation represents the *Cardiograptus* Zone, and at an unnamed creek 17 km northwest of the Akutlak Composite Section, 4 m of a stratigraphic section document the zone at three levels (Appendix D, 144–148 m).

Darriwilian Stage

During the early 1900s, Hall's (1899) Darriwil "Series" was considered the uppermost "Series" of the Lower Ordovician. Later, Harris (1935) revised it to be equivalent to the "Diplograptid Series" containing the four zones now used in Australasia (VandenBerg and Cooper, 1992):

Da4 *Hustedograptus teretiusculus* Zone
Da3 *Pseudoclimacograptus decoratus* Zone
Da2 *Undulograptus intersitus* Zone
Da1 *Undulograptus austrodentatus* Zone

Recently, the base of the *Undulograptus austrodentatus* Zone within the Huangnitang Section of southeastern China has been selected as the global stratotype point for the base of the internationally recognized second stage (the Darriwilian Stage) of the Middle Ordovician Series (Mitchell and Maletz, 1995; Mitchell et al., 1997). The top of the Darriwilian is defined by the base of the overlying *Nemagraptus gracilis* Zone. The present study follows this consensus and uses the first appearances of the genus *Undulograptus* to define both the base of the Darriwilian and the base of the *Paraglossograptus tentaculatus* Zone in the Glenogle Formation.

There seems to be no continuous stratigraphic sequence across the Da3–Da4 boundary in the classical region in Victoria. At one time (Harris, 1935), Da4 was divided into a lower *Glyptograptus euglyphus* Zone, and an upper *Glyptograptus teretiusculus* Zone, but that usage has been discarded (Webby et al., 1981), with VandenBerg and Cooper (1992) commenting that many of the specimens previously identified as *G. euglyphus* and *G. teretiusculus* actually belong to their taxon *Glyptograptus* n. sp. A. In New Zealand, Cooper (1979) used a twofold zonation of the Darriwilian in the Aorangi Mine area, namely, the *Paraglossograptus tentaculatus* Zone (which equates with Da1 plus Da2) and a *Diplograptus*? *decoratus* Zone (Da3). This scheme can be applied to the Glenogle faunas. Cooper's *Diplograptus*? *decoratus* Zone is about 450 m thick at the Slaty Creek Section, which is dominated by siltstone and sandstone. Faunas collected at six levels led Cooper (1979, p. 26, 27, 41, 97, 101, 107, 108) to propose lower and upper subdivisions (about 24 and 320 m thick, respectively) of this *decoratus Zone* within the Slaty Creek Section. The lower subdivision is characterized by *Pseudoclimacograptus decoratus*; this zonal designate was not reported from the upper subdivision within which *Hustedograptus* cf. *H. teretiusculus* is present near the top. The fossiliferous beds documenting these two subdivisions are separated by about

220 m of beds without any collections of graptolites. Later Cooper (*in* Webby et al., 1981, Pl. 1) discriminated all four Darriwilian zones in New Zealand with Da4, presumably representing the upper part of the 1979 *decoratus* Zone at Slaty Creek. However, *Hustedograptus* cf. *H. teretiusculus siccatus* is reported associated with *Pseudoclimacograptus decoratus* about 20 m above the base of the lower subdivision at Slaty Creek and thus may indicate Da4, with Da3 a very thin development below a very thick Da4. Subdivision of Da4 recently has been suggested in New Zealand with *Dicellograptus* and *Dicranograptus* appearing in Da4b but absent from the lower division Da4a (VandenBerg and Cooper, 1992).

An especially noteworthy feature of the Darriwilian in Australia and New Zealand is the massive turnover of taxa at the top of Da2. Cooper (1979) recorded an 80 per cent turnover at the top of the *Paraglossograptus tentaculatus* Zone in New Zealand. Similarly in Western Canada, Lenz and Jackson (1986) recorded a decline in numbers of taxa, from 52 in the upper part of the *Paraglossograptus tentaculatus* Zone to 14 in the *Pseudoclimacograptus decoratus* Zone. However, our detailed collecting in the Glenogle Formation shows quite convincingly that a single major extinction event does not exist. Instead, taxa disappear at several levels below the top of the *tentaculatus* Zone as shown by the data from Akutlak Creek (Fig. 36).

Paraglossograptus tentaculatus Zone (Da1 and Da2)

The zone is well developed in the Akutlak Composite Section (Fig. 36) where the appearance of *Undulograptus austrodentatus* marks the base at 265.8 m. *Paraglossograptus tentaculatus* first appears at 270.1 m and is very common above, ranging up to 361.3 m. The upper limit of the zone is placed below this level, at the first occurrence of *Pseudoclimacograptus decoratus* at 335.9 m. The *tentaculatus* Zone so defined is 70.1 m thick and contains a rich and diverse assemblage that includes *Cardiograptus morsus, Glossograptus acanthus, Isograptus forcipiformis, I. caduceus australis, I. caduceus nanus, I. victoriae divergens, Oncograptus upsilon, Pseudisograptus manubriatus, Pseudotrigonograptus ensiformis, Tetragraptus bigsbyi, Undulograptus austrodentatus americanus* and *U. austrodentatus austrodentatus*.

In the Headwaters of Windermere Creek Section (Walker, 1926, p. 26, 27), the *tentaculatus* Zone is represented between 916 and 966 feet of Walker's measurements. The zone is well developed in the Diana Lake Section (Appendix D). On the west face of White Knight Mountain, collections made by Leech (1954, p. 15) document the *Cardiograptus* Zone, the *Paraglossograptus tentaculatus* Zone and the *Pseudoclimacograptus decoratus* Zone. The Mount Wilson Quartzite directly overlies the *P. decoratus* Zone indicating that erosion during the late Middle Ordovician caused beds with the higher Glenogle faunas to be missing.

At Kicking Horse River, the *Paraglossograptus tentaculatus* Zone outcrops along the railway cutting near Glenogle Halt (see Larson and Jackson, 1967, Plate 2, fig. 1) in a structurally complex zone where the beds are overturned locally. Stratigraphically significant elements of the rich fauna include *Paraglossograptus tentaculatus, Acrograptus* cf. *A. cognatus, Glossograptus echinatus, Pseudotrigonograptus ensiformis, Cryptograptus schaeferi, Holmograptus spinosus, Isograptus caduceus nanus, I. forcipiformis, Loganograptus logani, Pseudobryograptus incertus* and *Tetragraptus bigsbyi latus*.

Elsewhere in the White River Trough, the North Fork of Windermere Section, the Moscow Creek Section, and several other localities show the *P. tentaculatus* Zone following Yapeenian faunas but lacking unequivocal evidence of the overlying *Pseudoclimacograptus decoratus* and younger faunas (Fig. 4 and Appendix D). In the North White River Section (Fig. 37), the *Paraglossograptus tentaculatus* Zone includes shelly faunas of the *Orthidiella* Zone at 248.7–385.3 m within the carbonate-rich middle unit of the Lower Member of the Glenogle.

In the Pedley Pass Section (Fig. 1, 4-R), the Glenogle is only 40 m thick and lies disconformably beneath the Mount Wilson Quartzite. At 31–39 m above the base, taxa in the assemblage indicate that both the *P. tentaculatus* Zone and the *Pseudoclimacograptus decoratus* Zone are present within the sampled stratigraphic interval. The faunal list (Appendix D) includes *Acrograptus cognatus, Amplexograptus* sp., *Bergstroemograptus crawfordi, Cryptograptus* cf. *C. antennarius, C. schaeferi, Glossograptus echinatus, "Glyptograptus"* sp., *Holmograptus* sp., *Isograptus caduceus australis, I. forcipiformis, I.* cf. *I. victoriae maximodivergens, Loganograptus logani, L. logani pertenuis, Paraglossograptus tentaculatus, Pseudoclimacograptus riddellensis, Tetragraptus* cf. *T. serra, T.* cf. *T. bigsbyi* and *Pseudotrigonograptus ensiformis*.

Pseudoclimacograptus decoratus Zone (Da3)

The lower part of the range of *Pseudoclimacograptus decoratus* overlaps the upper part of the range of *Paraglossograptus tentaculatus* in the northern Yukon, British Columbia, Australia, and New Zealand. As in Australasia, the base of the zone is picked at the lowest occurrence of *P. decoratus*, which is some distance below its influx in abundance. In the Akutlak Composite Section, the base is picked at the lowest occurrence of *Pseudoclimacograptus decoratus* at 335.9 m, which is 25 m below the highest occurrence of *Paraglossograptus tentaculatus*.

Pseudoclimacograptus decoratus first enters in substantial numbers at 373.1 m, where *Paraglossograptus tentaculatus* is absent. *Cardiograptus?* sp. and *Pseudotrigonograptus ensiformis* range up into the lower part of the *decoratus* Zone where they are associated with *Amplexograptus differtus?*, *Brachiograptus etaformis*, *Cryptograptus schaferi*, *Glossograptus hincksii*, *"Glyptograptus"* sp., *Isograptus victoriae divergens*, *Loganograptus logani pertenuis*, *Pseudamplexograptus confertus*, *Pterograptus lyricus*, *P. sinicus*, *P. pusillus*, and *Tetragraptus bigsbyi*. The zone is at least 168.9 m thick but is overlain by a 159 m thick interval from which no diagnostic graptolites have been recovered.

Elsewhere in the White River Trough, the *decoratus* Zone is known from White Knight Mountain and also from the Kicking Horse River (Larson and Jackson, 1967, p. 496) where it is documented by *Cryptograptus schaeferi*, *Didymograptus serratulus*, *Glossograptus hincksi* and *Pseudoclimacograptus decoratus*. In the Headwaters of Windermere Creek Section, Ruedemann (*in* Walker, 1926, p. 26) listed *Climacograptus phyllophorus* (as *C. pungens*) from Walker's 1069, 1084, 1490, 1600 and 1627 foot levels. These beds probably represent the *decoratus* and possibly younger zones.

"Glyptograptus" euglyphus Zone (Da4)

"Glyptograptus" euglyphus is present in only one collection in the Akutlak Composite Section (at 663.9–666.9 m) and is accompanied by *Kalpinograptus ovatus* and several poorly preserved taxa including *Pseudoclimacograptus decoratus*? This faunule is 4 m below the base of the Upper Member and represents the youngest Ordovician graptolites yet known south of the Diana Lake region. No diagnostic graptolites have been collected from the 159 m of strata below this collection and those beds are tentatively assigned to the upper part of the *decoratus* Zone.

At the type locality of the Glenogle along Kicking Horse River, the *euglyphus* Zone apparently succeeds the *decoratus* Zone in a cutting a few metres east of the railway crossing Cable Creek and in the banks of Cable Creek itself (Larson and Jackson, 1967, p. 496). The assemblage includes *Amplexograptus* sp., *Cryptograptus schaeferi*, *Didymograptus?* sp., *Pseudoclimacograptus* cf. *P. decoratus*, *"Glyptograptus" euglyphus*, *Hustedograptus* cf. *H. teretiusculus* and *Glossograptus* cf. *G. hincksii*. The zone appears to exceed a hundred metres in thickness within an apparently homoclinally dipping succession in the banks of Cable Creek, but the shales are deeply weathered, their structure is uncertain and their graptolites poorly preserved. The presence of *"Glyptograptus"* cf. *"G". euglyphus* indicates the zone in the Judge Peak Section (see Appendix D) and Ruedemann (*in* Evans, 1933, p. 137) identified specimens as *Glyptograptus teretiusculus euglyphus* in the nearby Pinnacle Creek and Beard Creek areas. The presence of one specimen of *Dicellograptus* cf. *D. geniculatus* at Judge Peak indicates a horizon high in the zone, but graptolites representing the overlying *Nemagraptus gracilis* Zone have yet to be found at Judge Peak.

Gisbornian Stage

Nemagraptus gracilis Zone (Gi1)

The exposures dubbed the "Glenogle slate and flag quarries" by Ami (*in* Selwyn, 1892, p. 79A) were sampled by several collectors over some forty years. In 1913, delegates on a field trip of the 12th International Geological Congress collected graptolites from the railway cuttings and an adjacent creek (Allan, 1913). When Evans published Ruedemann's faunal lists in 1933, it became evident that a Normanskill fauna was present in the Glenogle in addition to Deepkill faunas. Among the drawings presented by Ruedemann in 1947 were those of *Azygograptus canadensis*, *Climacograptus antiquus bursifer*, *Corynoides gracilis perangulatus*, *C.* cf. *C. tricornis*, *Dicellograptus forceps*, *Glossograptus ciliatus* and *Thamnograptus capilliaris*; his revised faunal lists included *Climacograptus eximius*, *C. parvus*, *Dicellograptus sextans*, *Nemagraptus gracilis*, *N. exilis linearis*, and *Reteograptus geinitzianus*.

The main problem in assessing these early studies beside the Kicking Horse River near Glenogle Halt is that structural complications and stratigraphic positions were largely ignored, so it is difficult to verify which species truly were associated. Before the modern road was built, access to the south bank of the river would have been difficult. We assume that virtually all of the early collections were made from a small creek and adjacent exposures beside the railway on the north side (see Clark, 1926), and that many were from talus.

Within the National Type Collection of Invertebrate and Plant Fossils, a ten millimetre thick slab (GSC 12460), was collected by Ami in 1891 and later was mentioned by Ruedemann (1947, p. 274–275). The slab is from GSC locality 353. Burling (note written in 1949) commented that this was "The creek flowing into the Wapta River, ¼ mile west of Glenogle"; the creek now is known as Cable Creek, and Wapta River is the old name for the Kicking Horse River. The slab presents two associations that together form a diagnostic assemblage. The thermal maturity is high and preservation is poor, but the following identifications can be made:

Obverse: *Dicellograptus* sp.
Glossograptus sp.

Glossograptus? sp.
Glyptograptus? sp.
Leptograptus sp.
Thamnograptus capillaris

Reverse: *Dicellograptus* sp.
Glossograptus sp.
Glyptograptus? sp.
Leptograptus sp.
Nemagraptus cf. *N. gracilis*
?Protistograptus rectus
Reteograptus geinitzianus

This assemblage contains some of the youngest taxa ("Normanskill forms") identified by Ruedemann (1947, p. 103, etc.) from collections made by Ami and by Clark from the outcrops beside the Kicking Horse River. The associations of genera are typical of the *Nemagraptus gracilis* Zone as developed in northwestern Canada (see Lenz and Chen, 1985, p. 230, 233) and in northeastern Washington (Carter, 1989b, p. B26).

Larson and Jackson (1967, p. 496, 497, 499–501) attempted to unravel the relationships between the various outcrops beside the railway and along creeks on the north side of the river, and the roadside and riverbank outcrops on the south side. They documented the *N. gracilis* Zone at 170–220 feet (a 15 m interval) in an apparently overturned section along the side of the road (Fig. 39) and the adjacent riverbank with a composite faunal list (here revised) of *Amphigraptus*? sp., *Climacograptus* sp., *Cryptograptus schaeferi*, *Dicellograptus* cf. *D. sextans*, *D.* cf. *D. smithi*, *Dicranograptus* sp., *Didymograptus sagitticaulis*, *Glossograptus hincksii bispinatus*, *G. ciliatus douglasi*, *G. hincksii*, *G.* cf. *G. whitfieldi*, *Hustedograptus* cf. *H. teretiusculus*, *Parabrograptus tribrachiatus* and *Reteograptus geinitzianus*. Later Norford collected *Nemagraptus* cf. *N. gracilis* associated with *Dicellograptus* sp., *"Glyptograptus"* sp. and *Leptograptus* sp. from a 10 cm interval (GSC loc. C-107954) at river level near the base of this interval (locality A of Larson and Jackson, 1967, Pl. 2, fig. 3). This fossiliferous interval appears to be near the top of the Lower Member of the Glenogle Formation (Larson and Jackson, 1967, p. 491, Fig. 3).

Figure 39. *Roadside outcrops of upper part of Lower Member, TransCanada Highway by Kicking Horse River near Glenogle Halt. Outcrop shows about 60 m of beds; talus from highway development since has covered most of the riverbank outcrops (including a bed with* ***Nemagraptus*** *cf.* ***N. gracilis****) shown in Plate 2, Figure 3 of Larson and Jackson, 1967 (GSC photo no. 3354-21).*

The *N. gracilis* Zone may extend south to the Diana Lake region where Evans (1933, p. 137) reported Ruedemann's identification of *Dicellograptus sextans* in a composite list of material from Pinnacle Creek and Beard Creek. However, a single identifiable specimen of the small species *Dicellograptus* cf. *D. geniculatus* has been found high in the *"Glyptograptus" euglyphus* Zone of the Judge Peak Section, which is near Pinnacle Creek, and several small species of *Dicellograptus* are present in the uppermost Darriwilian (Da4b) of New Zealand (VandenBerg and Cooper, 1992).

CORRELATION WITH OTHER GRAPTOLITIC SEQUENCES

During the Early and Middle Ordovician, the Pacific Province covered a broad equatorial belt that included Australasia, China, northeastern Siberia, Spitsbergen, and South and North America. Australia and New Zealand provide the basic biostratigraphic model for the Pacific Province with the key successions located in Victoria and northernmost South Island (Fig. 35). These successions are in structurally complex terranes both in Australia and in New Zealand and many of the stratigraphic sections are isolated and contain substantial intervals of unfossiliferous rocks. Despite these imperfections, within the Pacific Province, the sequences of faunas in the White River Trough and in Australasia are very similar (Fig. 35). Many papers have dealt with the correlations between the Atlantic Province and the Pacific Province; good accounts are found in Cooper and Fortey (1982), Williams and Stevens (1988), Cooper and Lindholm (1990), and VandenBerg and Cooper (1992).

The age of the Glenogle Formation extends from Bendigonian to Gisbornian time and, although no unconformities have been recognized within its succession, gaps exist in the sequence of graptolite faunas at two stratigraphic intervals: Be2 to Be4 and Ca1 to Ca2 (Fig. 35). These gaps may be due to inadequate collecting, to local environmental conditions inhospitable to graptolites, or to some other reasons.

The Bendigonian fauna from the Diana Lake area comprises *Pendeograptus fruticosus*, *T. approximatus*, and *T. acclinans*, and can be correlated with Be1, the *Pendeograptus fruticosus* and *Tetragraptus approximatus* Zone, of Australia. However, the fauna could represent the *Tetragraptus akzharensis* Zone of western Newfoundland, which is thought to represent most of Be1, all of Be2 and lower Be3 (Williams and Stevens, 1988, p. 15).

Didymograptus bifidus, *Perissograptus pygmaeus* and slender sigmagraptines are present in the Chewtonian *Didymograptus bifidus* Zone, which correlates well with the Australian Ch1 and possibly Ch2. The index species of Ch2 in Australia, *Isograptus primulus*, is not present in the Glenogle Formation.

The Castlemainian *Isograptus victoriae maximus* Zone is characterized by the incoming of *I. v. maximus*, *I. v. maximodivergens*, *I. caduceus imitatus* and *Pseudotrigonograptus ensiformis* and is correlated with Ca3 and Ca4 of Australia. The earlier Ca1 and Ca2 zones have not been documented in the Glenogle but may be present within an apparently unfossiliferous 50 m thick interval in the Akutlak Creek Composite Section.

Yapeenian faunas are readily recognized in the Glenogle Formation by the presence of *Apiograptus*, *Cardiograptus*, *Didymograptus*? *v-deflexus*, *Isograptus caduceus australis* and *Oncograptus*. Differentiation into the Ya1 and Ya2 zones of Australasia has been effected within the Akutlak Creek Composite Section (Fig. 36), based mainly on the first appearances of the two zonal designates, respectively *Oncograptus* and *Cardiograptus*. Most of the other Yapeenian localities in the Glenogle Formation are considered to represent the *Cardiograptus* Zone. In Australia, very few Ya1 species fail to range up into Ya2 (VandenBerg and Cooper, 1992) and Ya2 is recognized by the incoming of several taxa in addition to *Oncograptus* itself. Glenogle faunas that lack these taxa could belong to either zone.

An *Oncograptus* Zone in the Ledbetter Slate of northeastern Washington (Carter, 1989b) contains *Apiograptus* cf. *A. crudus* and may include equivalents of the Glenogle *Cardiograptus* Zone. In western Texas, Berry (1960) recorded taxa within his *Isograptus caduceus* Zone of the Fort Peña Formation that indicate the presence of Yapeenian faunas. In particular, *Oncograptus upsilon* is present in his collections 61B and 110, and *Cardiograptus morsus* and *Diymograptus*? *v-deflexus* from collections 107, 140 and 141. Berry's *I. caduceus* Zone appears to correlate with the *I. victoriae maximus*, *Oncograptus* and *Cardiograptus* zones of the Glenogle Formation. The Precordillera of Argentina contains the *Oncograptus upsilon* and *Cardiograptus morsus* zones (Ortega and Albanesi, 1999), which are similar to the two Glenogle zones except for the upper part of the *C. morsus* Zone including the first appearences of *Paraglossograptus tentaculatus* and *Undulograptus* sp. The early Darriwilian *Paraglossograptus tentaculatus* Zone of the Glenogle is equivalent to the Australasian *Undulograptus austrodentatus* (Da1) and *U.*? *intersitus* (Da2) zones. In both regions the base of the Darriwilian is marked by the presence of diplograptids, *Paraglossograptus tentaculatus* and species of *Glossograptus*. The rarity of diplograptids and the abundance of *P. tentaculatus* in the Glenogle is more similar to New Zealand faunas than to those of Australia.

The overlying *Pseudoclimacograptus decoratus* Zone of the Glenogle Formation clearly represents the Australasian Da3. A final burst of dichograptids in the Glenogle, represented by *Brachiograptus*, *Loganograptus*, *Pseudobryograptus* and *Pterograptus* is also present in Australia.

The *"Glyptograptus" euglyphus* Zone is not well known in the Glenogle Formation. *Pseudoclimacograptus decoratus*, *"Glyptograptus" euglyphus* and *Kalpinograptus ovatus* are found together in one collection from the Akutlak Composite Section; in Australia this association would seem to indicate the boundary between Da3 and Da4, but those two zones have never been found together within the same stratigraphic section (VandenBerg, 1981, p. 5). At Judge Peak, a faunule that can be interpreted as very high *euglyphus* Zone includes *"Glyptograptus"* cf. *"G." euglyphus*, *"G."* aff. *"G." teretiusculus* and rare *Dicellograptus* cf. *D. geniculatus*. Associated conodonts indicate the *Pygodus serra* Zone of late Darriwilian age.

The Gisbornian *Nemagraptus gracilis* Zone is the highest graptolite zone within the Glenogle and has been firmly documented only from the outcrops beside the Kicking Horse River, where stratigraphic relationships are uncertain. Larson and Jackson (1967) considered their section DJ-1-62 (south bank of the river and adjacent roadcut; Fig. 39) to be overturned. A bed near the base of their section contains both *Nemagraptus* cf. *N. gracilis* and *Dicellograptus* sp. and this bed underlies several beds bearing dicellograptids. If they were mistaken, and the outcrops are in normal sequence, then these dicellograptids occur below *Nemagraptus*, as they do in eastern Wales (Hughes, 1989), in central Alaska (Carter, 1996) and in the Da4b Zone of Victoria (Fig. 35; VandenBerg, *ibid.*, fig. 2), prior to the first occurrences of *N. gracilis* itself. In central Alaska, within the type section of the Post River Formation, the lowest occurrence of *Dicellograptus* is about 20 m stratigraphically below that of *Dicranograptus*, which is about 10 m below the lowest occurrence of *Nemagraptus* (Carter, 1996). *Climacograptus bicornis* commences about 30 m higher than the first occurrence of *Nemagraptus* in the Post River Formation (Carter, 1996); despite extensive collecting, this readily

recognizable species has never has been reported from the Glenogle Formation. In Victoria, *C. bicornis* is present and locally abundant in the middle and upper Gisbornian (VandenBerg, *ibid.*, fig. 2) and therefore the Glenogle *gracilis* Zone probably represents only the lower Gisbornian. *Nemagraptus gracilis* has been reported from only a few localities in New Zealand (Skwarko, 1962, p. 227–228; Cooper, 1979, p. 84, 118); *C. bicornis* is not associated.

Ordovician graptolitic facies are widespread in northwestern Canada. In the Grey Peak Section (Cecile and Norford, 1979) of northeastern British Columbia, Lenz and Jackson (1986) recognized the *Tetragraptus approximatus*, *Tetragraptus fruticosus*, and *Didymograptus protobifidus* zones in the Road River Formation and also a distinct *Isograptus victoriae lunatus* Zone (Ca1) documented by the zonal index associated with *Didymograptus nitidus* and *Phyllograptus angustifolius* (GSC loc. C-78584 at 1616–1626 m of their Fig. 2). The sequence continues with a thick *Isograptus victoriae maximodivergens* Zone, followed by undifferentiated Yapeenian. The section ends within the *Paraglossograptus tentaculatus* Zone. In the same region, the *Glyptograptus euglyphus* and *Nemagraptus gracilis* zones have been reported below the *Climacograptus bicornis* Zone (Davies, 1966, p. 112, 115, 118) and probably a *Pseudoclimacograptus decoratus* Zone can be recognized (Jackson et al., 1965, p. 150).

Farther north, in Yukon Territory, the Road River Formation presents a well documented succession of graptolite zones from Lancefieldian to Chewtonian. The *Isograptus victoriae lunatus* and *I. v. victoriae* zones have not been recognized and the *I. v. maximodivergens* Zone may represent the whole Castlemainian. The overlying Yapeenian lacks any representatives of *Oncograptus* and *Cardiograptus*. Above these beds, Lenz and Chen (1985) modified the zonation presented by Lenz and Jackson (1986): the top of the *Paraglossograptus tentaculatus* Zone was drawn higher than in the Glenogle and included early occurrences of *Pseudoclimacograptus decoratus*; their *P. decoratus* Zone corresponds to most of Da3; the *Glyptograptus euglyphus* Zone essentially corresponds to the Glenogle zone of the same name; *Nemagraptus* and dicellograptids seem to appear together at the base of the *Nemagraptus gracilis* Zone, which corresponds to the Glenogle *N. gracilis* Zone and to Gi1 of Victoria. However the Road River *N. gracilis* Zone lacks *Climacograptus bicornis*, which is the index of the overlying zone.

To the west, detailed correlation is not attempted with the Ordovician rocks of central Alaska, the Alaskan panhandle and northwestern British Columbia, which are within terranes accreted to the North American continent. In northeastern Washington, the structurally complex terrane of the Kootenay Arc represents the most westerly part of ancestral North America. The arc continues northward into southern British Columbia. Carter (1989a, b) documented occurrences of zones in the Ledbetter Slate of Washington State that are similar to the upper zones within the Glenogle Formation. An *Oncograptus* Zone includes *Cardiograptus morsus* but lacks *Oncograptus* iself. This is followed by the *Paraglossograptus tentaculatus* Zone, the *Diplograptus? decoratus* Zone, a *Nemagraptus gracilis* Subzone, a *Climacograptus bicornis* Subzone and younger Ordovician zones.

The graptolite facies of east-central Alaska represents a lateral continuation of the Road River Formation. In the Arctic Islands, Arenig and younger graptolitic faunas are present in the Ibbet Bay Formation on Melville Island, but zonal discrimination has not yet been achieved. In northwestern Greenland, most of the Cordilleran graptolites zones can be recognized, including the *Isograptus victoriae lunatus* and *Oncograptus* zones (Bjerreskov, 1988).

Western Newfoundland presents an excellent succession of Arenig continental margin facies in the Cow Head Group, followed by clastic rocks of the Lower Head Formation and by platform facies of the Table Head Group. The sequence of graptolite zones documented by Williams and Stevens (1988) from the Cow Head Group has been readily correlated with the Australasian La3 to Da1 succession and is more complete than the corresponding interval within the Glenogle Formation. Besides having complete representation of the Bendigonian and Castlemainian zones, the principle differences from the Glenogle succession are two. Firstly, Williams and Stevens (1988) erected a *Tetragraptus akzharensis* Zone of late Be1 and Be2 age. Faunas from a thin interval at the base of the Glenogle Formation of the Diana Lake area can be correlated with part of this zone. Secondly, typical Yapeenian faunas were not found above the *Isograptus victoriae maximus* Zone, and Williams and Stevens (1988) concluded that the Yapeenian Stage was represented by non-graptolitic red and green mudstone and carbonate conglomerate together with the upper part of their *I. v. maximus* Zone. Noteworthy is the lack of *Cardiograptus* and *Oncograptus*, but Cooper et al. (1991) suggested that these genera were restricted to relatively deep water and that the depositional environments in western Newfoundland (and also in Spitsbergen) were too shallow for them to be present.

Elsewhere in western Newfoundland, the *Pseudoclimacograptus decoratus* Zone is present at Table Head (Finney and Skevington, 1979; Maletz, 1994) and a faunule from Port au Port Peninsula includes *Glossograptus hincksii* (Whittington and Kindle, 1963) and may represent the *euglyphus* Zone.

TRILOBITE, BRACHIOPOD AND OTHER SHELLY FAUNAS AND THEIR BIOSTRATIGRAPHY

Benthic fossils are rare in the Glenogle Formation and are mostly found adjacent to the carbonate platform of the Bow Platform. Trilobites, articulate and inarticulate brachiopods, echinoderm debris, cephalopods, gastropods and sponges are present in limestone and argillaceous limestone near the North White River Section close to the Bow Platform. Sponge spicules, inarticulate brachiopods, the arthropod *Caryocaris*, and rare trilobites and articulate brachiopods are known from argillaceous limestones and shales in many parts of the White River Trough.

Glenogle faunules characterized by trilobites and articulate brachiopods are important biostratigraphically. Relationships to graptolite zones are documented locally, especially by the North White River Section. The Ordovician shelly faunas of the upper McKay Group are only known in a reconnaissance fashion. Tremadoc and Arenig Zones A, B, D, E, F, G and J are known to be present (Fig. 35; Aitken and Norford, 1967, p. 184; Dean, 1988). The top of the McKay Group may be synchronous in much of the region and within Zone J but, at least in parts of the Brisco Range, the contact between the McKay and the Glenogle locally is older (Fig. 4). The *Tetragraptus approximatus-Pendeograptus fruticosus* Zone is present at the base of the Glenogle in the Diana Lake Section, and trilobites and cephalopods indicate trilobite zones G or H in the top beds of the McKay in the nearby Judge Peak Section. Another exception to the regional pattern is at Pedley Pass in the Stanford Range, where the *Didymograptus bifidus* and the *Isograptus victoriae maximus* zones are extremely thin or absent and the uppermost McKay beds may be younger than elsewhere and represent much of the duration of these two zones.

The uppermost 10 cm of the McKay Group beneath the Glenogle Formation of the Akutlak Creek Composite Section contains the asaphid trilobites, *Ampyx?* and *Microagnostus?*, and can be correlated with V2a and V2b in Spitsbergen, which are correlated by Fortey (1980) as high Chewtonian; i.e., *Didymograptus bifidus* Zone of the Glenogle scheme, which is documented 6 m higher within the Glenogle of the same section (Fig. 36). *Carolinites* cf. *C. genacinaca genacinaca* is associated with *Didymograptus bifidus* low in the Glenogle near Bull River (GSC loc. C-108000) and with *D.* cf. *D. bifidus* and *Lachnostoma latucelsum* at Tipperary Lake (GSC loc. 57204, 57205). The species ranges from V1b to V2a in Spitsbergen and is present in Zone J of the Outram Formation of the Bow Platform at Mount Wilson and Wilcox Pass (Dean, 1990). It was described from Utah from Zone J (Ross, 1951), reported from Zones I and J by Hintze (1952), and considered to be a global indicator of Zone J time by Fortey and Droser (1996).

The North White River Section shows interstratification of Arenig and Darriwilian shelly faunas with graptolites (McKee et al., 1972; Norford and Ross, 1978). *Peraspis?* sp. (which could indicate Valhallan or Whiterockian, V3a upward), inarticulate brachiopods, and *Caryocaris* are known from the *Didymograptus bifidus* Zone (basal unit of the Lower Member of the Glenogle). The *Isograptus victoriae maximus* Zone (middle unit of the Lower Member of the Glenogle) has yielded poorly preserved inarticulate and articulate brachiopods and rare trilobites and cephalopods. The basal *Oncograptus* Zone contains *Globampyx sinalae*, *Peraspis kolouros* and undetermined asaphacean trilobites, the ostracode cf. *Primitiella* sp., articulate and inarticulate brachiopods, and cephalopods. This faunule indicates correlation with the late Valhallan and Whiterockian of Spitsbergen (probably V4a or V4b) and with the *Paralenorthis-Orthidiella* Zone (Whiterockian) of North America (Fig. 35). Higher, a stratigraphic interval about 235 m thick of the middle unit of the Lower Member and the lower two thirds of its limestone unit has yielded a rich fauna of trilobites and brachiopods, with associated gastropods, conulariids, cephalopods, sponges, and echinoderm debris. This also is a *Paralenorthis-Orthidiella* Zone assemblage and is known from several nearby localities (GSC loc. 57482, 57559, 57561, C-82891, C-82898, C-137721, C-137722, C-137739, C-137740, C-147475A, C-147476). A composite faunal list includes:

Lingulella? sp.
Camarella sp.
Diparelasma? sp.
Orthidiella cf. *O. carinata*
O. cf. *O. extensa*
Orthidium sp.
Paralenorthis marshalli
"Plectorthis" sinuatis
Syntrophina? sp.
Syntrophopsis sp.
Carolinites sp.
Cybelurus sp.
Ectenonotus westoni
E. cf. *E. whittingtoni*
Goniotelina sp.
Illaenus sp.
Isoteloides? sp.
Kawina sp.
aff. *Lehua* sp.
Micragnostus? sp.
Nileus? sp.
Peraspis sp.
Pliomerops sp.
Protocalymene? sp.

"Protopliomerops" subquadratus
Punka? sp.
Raymondaspis? sp.
Scotoharpes sp.
Sycophantia? sp.
Eoleperditia cf. *E. bivia*
Ribeiria sp.
Discoceras? sp.
Archaeoscyphia cf. *A. minganensis*
Calycocoelia? sp.
Hindia cf. *H. sphaeroides*

Correlation is with the early Whiterockian *Paralenorthis-Orthidiella* Zone of Alberta (Rohr et al., 1995) and of Nevada (Fortey and Droser, 1996, 1999; Ross et al., 1997) and with the V4b fauna (early Whiterockian; Fortey, 1980) of Spitsbergen. In the North White River Section, the lower half of this interval contains graptolites of the *Paraglossograptus tentaculatus* Zone. No biostratigraphically useful graptolites are known from higher in the North White River Section, but the following benthic fauna is present in the 91 m interval above the *Paralenorthis-Orthidiella* Zone in rocks of the Skoki Formation and of the underlying upper third of the limestone unit of the Lower Member of the Glenogle (see Norford and Ross, 1978):

sponges
Desmorthis? sp.
Hesperomena canadensis
leptaenid and other brachiopods
cheiruriniid and other trilobites
Nileus sp.
undetermined gastropods
Maclurites sp.
Pararaphistoma? sp. (Yochelson, pers. comm., 1978)

Correlation is with the *Anomalorthis* Zone of Alberta and Nevada.

A debris flow within the Lower Member of the Glenogle near Pedley Pass provides samples of shallow-water carbonate deposited on the Purcell Arch, to the west of the White River Trough. A composite faunal list from boulders sampled by Gerard C. Bond includes *Anomalorthis?* sp., aff. *Leptellina* sp., *"Plectorthis"* cf. *"P." sinuatis*; undetermined gastropods, bryozoans, cephalopods, brachiopods, echinoderm debris, and abundant sponges. The aggregate age is Whiterockian; graptolites of the *Paraglossograptus tentaculatus* Zone are present 3 m below the flow.

In the middle of the limestone unit of the Lower Member of the Glenogle Formation of the Akutlak Composite Section (GSC loc. C-107993), *Peraspis* sp., *P.* aff. *P. erugata* and *Telephina* sp. are associated with indeterminate inarticulate and articulate brachiopods. The beds are about 76 m below the only documentation of the *"Glyptograptus" euglyphus* Zone in the section and about 79 m above the highest record of the *Pseudoclimacograptus decoratus* Zone. The trilobites are Darriwilian, and comparison can be made with Kobayashi's identifications of *Ampyx* sp. b, *Telephina pacificus*, and *Trinodus tardiformis* (GSC loc. 8118; Evans, 1933, p. 130; Kobayashi, 1955) from an unspecified horizon near Mount Kindersley in the Brisco Range. Nearby, Kobayashi (1955, GSC loc. 8117) described *Peltura pacifica* and an indeterminate nileid as also from the Glenogle, but their stratigraphic position is uncertain.

In Spitsbergen (Fortey, 1980), *Peraspis erugata* is present in faunas V4a and V4b (Fig. 35); in Nevada, in the *Paralenorthis-Orthidiella* Zone (Fortey and Droser, 1996). In Newfoundland, *Peraspis lineolata*, *Telephina americana* and *T.* sp. are known from the Middle Table Head Formation but not from the Lower Table Head (Whittington, 1965, p. 283–287) that contains *Ectenonotus westoni* and *Kawina* sp. The Akutlak faunule can be considered as a deeper water representation of the *Anomalorthis* Zone of the North White River Section and both can be correlated with the Middle Table Head Formation of Newfoundland.

Some genera of trilobites typical of deep-water environments are present high in the *euglyphus* Zone near the top of the Lower Member of the Glenogle Formation of the Judge Peak Section (Appendix D). *Mendolaspis* aff. *M. salagastensis*, *Robergia* sp. and *Triarthrus* cf. *T. pacificus* are present within a thin, aphanitic limestone bed. A directly overlying calcarenite contains the same taxa and *Trinodus?* sp. and undetermined asaphid and harpid trilobites together with fragments of brachiopods, byrozoans, and echinoderms that appear to have been transported from a platformal environment. The trilobite genera are long ranging but the assemblage indicates a general early Middle Ordovician age.

CONODONT BIOSTRATIGRAPHY

Three stratigraphic sections of the Glenogle Formation and the uppermost McKay Group were sampled for conodonts: the Akutlak Creek Composite Section, the North White River Section and the Judge Peak Section (Fig. 1, 8, W, Z and F'). Forty-six samples were processed and thirty of these produced conodonts, but only a few collections yielded abundant specimens (see Table 2 for distributions of conodont specimens and numerical data for taxa). Identifications for an additional sample from the North White River Section were reported informally by C.R. Barnes in 1980. The sample has been kindly made available by Barnes for restudy by Nowlan. A few additional samples from the Skoki Formation and from the Tipperary Quartzite from other localities are discussed. Samples vary widely in mass (100–4,795 g, see Table 2); the smaller

Table 2
Data on conodont specimens and taxa

| | Akutlak Creek Composite Section | | |

Bergstroemognathus sp.
Cristodus loxoides
Drepanodus arcuatus
Jumudontus brevis
Paroistodus parallelus
Prioniodus elegans
Protopanderodus rectus
Scolopodus krummi
Tripodus? n. sp. A

The fauna is indicative of the *Prioniodus elegans* Zone of the North Atlantic Faunal Realm and is late Ibexian (Blackhillsian) in terms of the Midcontinent Faunal Realm.

The occurrence of this fauna in the Akutlak Creek Composite Section is associated with trilobites that indicate correlation with the V2a and V2b faunas of Spitsbergen (Fig. 35). In the Akutlak Creek Composite Section, graptolites of the *Didymograptus bifidus* Zone occur 14 m above this conodont fauna.

The numerous specimens referred to *Tripodus?* n. sp. A (Pl. 3, fig. 20–30, 32, 33) represent a new species thought to occur earlier than *Tripodus laevis*, which marks the base of the type Whiterockian Series in Nevada. This new taxon may be part of a lineage of simple cone species within the latest Ibexian and early Whiterockian that is under study but has yet to be fully defined (R. L. Ethington, pers. comm., 1999). The lineage culminates with the appearance of *Tripodus laevis*.

A sample (Table 2, GSC loc. C-23470) from the top 1.5 m of the McKay Group in the North White River Section was reported informally by Barnes (1980) to contain the biostratigraphically diagnostic species *Oepikodus evae*. In the Atlantic Faunal Realm, the *Oepikodus evae* Zone succeeds the *Prioniodus elegans* Zone and the biostratigraphic ranges of the two nominate species generally do not overlap (Löfgren, 1978). This identification indicated that the top beds of the McKay Group at the North White River Section could be younger than the top beds at the Akutlak Creek Composite Section. Re-examination of the specimens of *Oepikodus* from GSC loc. C-23470 (Table 2, Appendix D) indicates that they likely are not assignable to *O. evae*. Instead, a few of the specimens are referable to *O. intermedius*, whereas the majority are not identifiable to the species level and are termed *Prioniodus* sp. It is possible that these latter specimens are assignable to *P. elegans* but the preservation is inadequate for such identification. The reassessment of the conodonts from GSC loc. C-23470 indicates that the conodont faunas from the top beds of the McKay Group at both the North White River and the Akutlak Creek Composite sections are similar in age. Graptolites of the *Didymograptus bifidus* Zone are present at the North White River Section, 3 m above the beds of GSC loc. C-23470.

Small phosphatic gastropods (Pl. 3, fig. 35) are characteristic of the faunas of the uppermost beds of the McKay Group at both the Akutlak Creek Composite Section and the Judge Peak Section.

Glenogle Formation, Lower Member, basal unit

The basal unit was sampled only at the North White River Section. One of the three samples yielded conodonts (Table 2, GSC loc. C-23471):

Drepanodus arcuatus
Jumudontus ganada
Oepikodus intermedius
Paroistodus originalis
Paroistodus parallelus
Paroistodus horridus primus?
Tripodus? n. sp. A
indet. simple cone elements

This fauna is abundant, numerically dominated by *Tripodus?* n. sp. A and has similarities to that of the uppermost beds (GSC loc. C-107996) of the McKay Group at the Akutlak Creek Composite Section. The fauna at the North White River Section indicates a late Ibexian (late Arenig) age for the basal unit. The *Didymograptus bifidus* Zone is documented 2 m above and 19 m below the conodont fauna. The conodonts have mixed provincial affinities and indicate a deep-water, perhaps marginal shelf setting. The specimens identified as *Paroistodus horridus primus?* (Pl. 2, fig. 3) are generally similar to the type material described by Albanesi (1998) from the Llanvirn *Lenodus variabilis* Zone of Argentina, possibly suggesting a younger age. The main differences are that the Glenogle specimens have a more angular anterobasal corner and the posterior denticle originates higher on the oral margin of the base, rather than at the postero-oral margin.

Glenogle Formation, Lower Member, cherty quartz siltstone unit

Two samples from an interval spanning the top 6 m of the unit and the basal 4 m of the overlying middle unit in the Akutlak Creek Composite Section (Table 2, GSC loc. C-107977, C-104101) yielded the following taxa:

Drepanoistodus basiovalis
Oistodus aff. *O. multicorrugatus*
Parapanderodus gracilis

Periodon aculeatus
Protopanderodus rectus
Protoprioniodus aranda
Trigonodus sinuosus

This fauna has mixed provincial affinities and indicates a late Ibexian to early Whiterockian (late Arenig) age, based on the range of *P. aranda* in Utah (Ethington and Clark, 1982; Ross et al., 1997). This age is in accord with that provided from graptolites in the same interval in the section that indicate the *Isograptus victoriae maximus* Zone.

Conodont faunules recovered from the Tipperary Quartzite and the Skoki Formation on the Bow Platform [Russell Peak (Fig. 4-ZW) and southwest of Shatch Mountain] contain slightly older, long-ranging conodonts (late Ibexian, Tulean to Blackhillsian; late Arenig). These faunules include *Oneotodus costatus*, *Toxotodus carlae*, and *Tropodus australis*, indicating a range from the *Acodus deltatus-Oneotodus costatus* Zone to the *Jumudontus gananda-Reutterodus andinus* Zone.

Glenogle Formation, Lower Member, middle unit

Several biostratigraphically significant conodont faunas occur within the middle unit. The lowest (Table 2, GSC loc. C-107978) is from 130.5–134.7 m within the Akutlak Creek Composite Section and includes the biostratigraphically diagnostic *Protoprioniodus aranda*. The age is latest Ibexian (*Jumudontus gananda-Reutterodus andinus* Zone) to earliest Whiterockian (*Tripodus laevis* Zone). *Protoprioniondus aranda* also documents the *J. gananda-R. andinus* Zone in the underlying cherty quartz siltstone unit.

A higher fauna was recovered from the lower part of the middle unit of the Akutlak Creek Composite Secton (Table 2, GSC loc. C-104104) at 257.9–258.8 m:

Histiodella minutiserrata
Periodon aculeatus
Protopanderodus rectus
Tricladiodus sp.
Trigonodus sinuosus

Histiodella minutiserrata is known from a narrow stratigraphic interval within the early Whiterockian *Histiodella altifrons* Zone (Ross et al., 1997; Albanesi et al., 1998). In Utah it is associated with trilobites that indicate Zone M (Ethington and Clark, 1982). *Trigonodus sinuosus* is typical of the upper part of the *Tripodus laevis* and the *Histiodella altifrons* zones; the other taxa are longer ranging species. The conodont fauna has mixed affinities with the Atlantic and the Midcontinent faunal realms; its latest Arenig age is confirmed by occurrences of graptolites of the *Cardiograptus* Zone within the collection interval and of graptolites of the *Oncograptus* Zone about 5 m lower.

At the North White River Section, there has been generally poor recovery of conodonts from the lower part of the middle unit, but one sample (Table 2, GSC loc. C-92589) from the 195.7–196.2 m interval contains the Midcontinent Faunal Realm species *Pteracontiodus cryptodens*, which indicates earliest Whiterockian (*Tripodus laevis* to *Histiodella altifrons* zones). Brachiopods from the same interval indicate the *Paralenorthis-Orthidiella* Zone. A higher sample from 396.2–397.7 m in the North White River Section (Table 2, GSC loc. 64572) includes abundant *Periodon aculeatus* and a few specimens of *Histiodella kristinae* (Plate 1, fig. 19, 20). In Newfoundland, the latter is present in the Whiterockian Table Head Formation (Stouge, 1984) within the *Histiodella holodentata* and *Eoplacognathus suecicus* zones, as used in the present paper. The Glenogle collection at 396.2–397.7 m is bracketed by *Paralenorthis-Orthidiella* Zone assemblages and is 11 m above graptolites of the *Paraglossograptus tentaculatus* Zone.

No conodonts have been recovered from the 262.7–424.3 m interval of the Akutlak Creek Composite Section, but a sample from 427.3–434.5 m (Table 2, GSC loc. C-107967) in the upper part of the middle unit, yielded a sparse fauna including elements of *Paroistodus horridus horridus* (Plate 2, fig. 1, 2). Within the evolutionary lineage of subspecies that has been described by Albanesi (1998), this taxon commences within the *Lenodus variabilis* Zone at a level approximately coeval with the base of the *Histiodella holodentata* Zone and extends into the *Eoplacognathus suecicus* Zone. The stratigraphic interval of the conodont collecton includes occurrences of graptolites of the *Pseudoclimacograptus decoratus* Zone and directly overlies documentation of the *Paraglossograptus tentaculatus* Zone. A single specimen (Plate 1, fig. 16) of the biostratigraphically useful genus *Eoplacognathus* was recovered from 436.2–443.2 m (Table 2, GSC loc. C-107970), just above GSC loc. C-107967, but is not identifiable to species. The higher part of the middle unit is not well dated on the basis of conodonts but specimens of *Periodon aculeatus* locally are common (Table 2).

Glenogle Formation, Lower Member, limestone unit and equivalents

The biostratigraphically diagnostic conodont *Phragmodus flexuosus* is present in samples from the lower part of the limestone unit in both the Akutlak Creek Composite Section and the North White River Section. Other common taxa are *Ansella jemtlandica* and *Periodon aculeatus*. These species

represent an admixture of the Midcontinent and Atlantic faunal realms and indicate an outer shelf or slope environment for the limestone unit.

Phragmodus flexuosus indicates the *Cahabagnathus friendsvillensis* to early *Plectodina aculeata* zones of Llanvirn (late Darriwilian) to early Caradoc age (Sweet, 1982). Occurrences of the species in the Akutlak Creek Composite Section are about 61 m above graptolites of the *Pseudoclimacograptus decoratus* Zone and about 92 m below graptolites of the *"Glyptograptus" euglyphus* Zone. One sample with *P. flexuosus* (Table 2, GSC loc. C-107972) also contains two specimens of *Paraprioniodus costatus*; this species has its earliest occurrence in the late Whiterockian of the Great Basin (Ross et al., 1997).

At 437.00–437.05 m in the Judge Peak Section (Table 2, GSC loc. C-147855), conodonts from near the top of the Lower Member are associated with graptolites that indicate a level high in the *"Glyptograptus" euglyphus* Zone. The assemblage contains conodonts diagnostic of the *Pygodus serra* Zone, including *P. serra* (Plate 3, fig. 7–10). This faunule provides an excellent link between biostratigraphic zonations based on conodonts and graptolites. The conodonts' affinity is with the Atlantic Faunal Realm, reflecting the basinal setting of the Judge Peak Section.

Glenogle Formation, Upper Member

Little is known of the conodont faunas of the Upper Member. Five samples were processed, four from the eastern facies of the Upper Member at the Akutlak Creek Composite Section and one from its western facies at the Judge Peak Section. The most common component is *Periodon aculeatus*, a species characteristic of the Atlantic Faunal Realm. In several samples, the species is associated with specimens that can be assigned to *Drepanoistodus*, *Panderodus* and *Protopanderodus*, but none of these can be identified at the species level. A single element of *Erraticodon balticus* was recovered from one sample from the Akutlak Creek Composite Section, just 2–4 m below the top of the Upper Member and of the Glenogle Formation (Table 2, GSC loc. C-107986); the species is not particularly diagnostic biostratigraphically, but its presence implies an age not older than late Llanvirn (Darriwilian). The youngest known graptolites from the Glenogle Formation indicate the *Nemagraptus gracilis* Zone. These are from high levels in the Lower Member at the Kicking Horse River outcrops and thus indicate that, in the western facies, the Upper Member is earliest Caradocian or younger in age. The abrupt influx of quartz silt and sand into the White River Trough can be interpreted as a virtually instantaneous event in early Caradoc time in both the western and eastern facies of the Upper Member.

Tipperary Quartzite and Skoki Formation

A few conodont faunas are known from the Tipperary and Skoki formations north of the North White River Section. Two samples from the Tipperary Quartzite near Russell Peak contain conodonts of late Ibexian age. The lower (GSC loc. C-147473, 153.9–158.9 m) contains a sparse fauna probably assignable to the *Oepikodus communis* Zone. A sample from higher in the same section (GSC loc. C-147474, 260.7–265.7 m) in the Skoki Formation yielded conodonts of the *Jumudotus gananda-Reutterodus andinus* Zone, including:

Jumudontus gananda
Oepikodus communis
Parapanderodus asymmetricus
Parapanderodus gracilis
Protopanderodus gradatus
Protoprioniodus aranda
Tropodus australis

A sample from beds transitional between the Tipperary and Skoki formations with a fauna typical of the *J. gananda-R. andinus* Zone, including both nominate species, is known in a section north of the North White River Section (GSC loc. C-147471, 167.5–177.5 m). Other key elements of this fauna are *Oepikodus communis* and *Protopanderodus gradatus*. An adjacent sample (GSC loc. C-147472, 177.5–187.5 m) contains an abundant and diverse fauna that includes the following taxa:

Bergstroemognathus extensus
Fahraeusodus marathonensis
Oepikodus communis
Protopanderodus graduatus
Protoprioniodus aranda
Reutterodus andinus
Toxotodus carlae

Together these two faunas indicate a latest Ibexian age for the Tipperary-Skoki transitional interval in this area.

THERMAL MATURITY

The least altered conodonts examined in the study are from the Judge Peak Section where the conodont colour alteration indices are in the range of 2.5 to 3 (CAI of Epstein et al., 1977; Rejebian et al., 1987; Nowlan and Barnes, 1987). Conodonts from the Akutlak Creek Composite Section have CAI values of 4 to 4.5. Those from the North White River Section have higher CAI values of 4.5 to 5 and the maximum reflectances of associated graptolites range from 7.93 to 11.86% (Goodarzi and Norford, 1985).

RESOURCE POTENTIAL

The depositional environment of the Glenogle Formation is very similar to those of sediments in other lower Paleozoic troughs in western and northwestern Canada that are marginal to carbonate platforms. Several of these troughs contain stratiform deposits of base metals. Rich deposits of lead and zinc are present within Lower Silurian rocks of the Road River Group at Howards Pass in the Yukon (Dawson et al., 1992). In the Gataga District of northeastern British Columbia, Middle Ordovician and Lower Silurian Road River rocks host barite, lead and zinc (McMillan et al., 1991). The White River Trough has similar potential. The present study included a search for concentrations of zinc throughout the Judge Peak Section of the Lower Member of the Glenogle Formation, testing for colour response at regular intervals with a field geochemical technique using potassium ferricyanide, oxalic acid and diethylaniline, but there were no positive responses.

The present-day thermal maturities of the Glenogle Formation (CAIs mostly 2.5 to 5; Ro_{MAX} 7.86–11.9%, Goordarzi and Norford, 1985, 1989) are mostly beyond the levels for generation of oil and gas. Organic content within the Glenogle Formation may have been a source of hydrocarbons and any petroleum generated may have migrated into carbonate reservoirs. However, later erosion documented by several unconformities most probably would have released any such oil and gas.

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APPENDIX A
Akutlak Composite Stratigraphic Section, White River, southeastern British Columbia
Fig. 1 (W), 3, 4, 7–16, 18–28, 36

At White River (Fig. 7), a complex and faulted syncline trends almost due north. In the east limb, the Mount Wilson Quartzite forms a vertical rib. The upper McKay Group is vertical at river level but northward, toward the ridge crest, minor folds are present near its contact with the Glenogle Formation. The Glenogle is the least competent unit in the Ordovician stratigraphic package. Faults and folds are present and it is possible that there is some tectonic inflation in the total thickness of 851 m. The ridge-crest sections (139/843/844/849/925NE, 50°10.75'–11.75'N, 115°20.75'–21.5'W) have excellent exposure of the whole of the Glenogle Formation and stratigraphic horizons can be matched across the several faults that are present.

Near river level, roadside outcrops show near-vertical Glenogle for most of the middle and lower thirds of the formation, but a minor fold (axially faulted) is present in the highest outcrops and is interpreted as a drag fold. Covered intervals, respectively 97 and 176 m thick, are present at the base and top of the roadside section (838NE, White River Section; 50°09'N, 115°21'W). The discrepancy between measured thicknesses of the upper half of the formation between ridge crest (844NE) and river level (838NE) may indicate that some part of the upper Glenogle is faulted out at river level.

The roadside section (838NE) was studied and collected in considerable detail and measured using tape and compass. Its relationship with the ridge-crest sections was established using the upper and lower boundaries of the middle unit of the Lower Member. The ridge-crest sections (843/844/849/925/111 NE) are difficult to negotiate and their graptolites are weathered. Except for the basal 200 m of 925NE, these sections were studied and collected in a reconnaissance manner and measured using a five-foot staff. Another section (842NE; 50°10'N, 115°21'W) is located in a side gulley west of Akutlak Creek and sampled the uppermost Glenogle; this also was measured using a five-foot staff.

The type sections of the Upper Member and the Lower Member are within the ridge crest sections of the Akutlak Creek Composite Section. The Lower Member can be divided into four units. A recessive basal unit of mudstone and shale rich in quartz silt laminae is followed by a cherty quartz siltstone unit that represents an influx of quartz silt and sand into the depositional environment. A thick recessive middle unit of argillaceous limestone and limy shale is followed by a limestone unit characterized by thinly bedded, platy weathering limestone. The Upper Member is dominated by brownish weathering carbonate rich in quartz silt and sand. River-level section 838NE spans the top of the cherty quartz siltstone unit, the middle unit, and the basal part of the limestone unit. Ridge crest section 844NE spans the limestone unit and the Upper Member; ridge crest sections 843/849/925NE cover the basal part of the middle unit, the cherty quartz siltstone unit and the basal unit with conformable contact with the McKay Group. Gulley section 842NE covers the upper part of the Upper Member. Figure 7 indicates the locations of these sections, Figure 8 their stratigraphic sequences and lithological equivalence. Numbers such as C-107986 refer to collections and localities recorded in the locality catalogue of the Geological Survey of Canada.

Summary

	Thickness in metres
Whiskey Trail Member of Beaverfoot Formation contact, assumed conformable	27
Mount Wilson Quartzite contact, disconformable with up to 2 m of relief and karst fillings to 70 m down	72.5
Glenogle Formation	851
Upper Member, (carbonate rich in quartz sand and silt): contact, gradational, picked on change in gross weathering characteristics	180
Lower Member	671
Limestone unit contact, gradational, picked on change in gross weathering characteristics	135
Middle unit (argillaceous limestone and limy shale) contact - conformable, picked at top of substantial silica content	405.5
Cherty quartz siltstone unit contact - comformable, picked at base of influx of quartz silt and sand	69.5
Basal unit (mudstone and shale with quartz silt laminae) contact - conformable, picked at top of carbonate	61
McKay Group	

COMPOSITE SECTION, AKUTLAK CREEK
Mount Wilson Quartzite (72.5 m)

Quartzite, medium- to coarse-grained, off-white, weathers off-white with lichen stains, resistant; bedding 0.3 to 3 m, rarely crossbedded; contact with up to 2 m of local erosional relief and with interpreted fissure fillings at 3 m and 70 m down into underlying rocks

Unit No.		Unit *Thickness* (m)	Cumulative *Thickness* (m)
	Glenogle Formation 851 m		
	Upper Member 180 m (studied at 844NE, supplemented by 842NE for upper Unit 17)		
18	**Dolomite:** somewhat limy and with substantial content of fine quartz sand and silt, very finely crystalline; dark brownish grey and brownish grey, weathers brownish grey, pale yellowish brown, greyish orange; bedding 30 to 90 cm; interbedded, thinly bedded, somewhat argillaceous and siliceous limy dolomite, bedding 2 to 15 cm; some cherty layers; silica blebs prominent (locally comprising 1%) in top 55 m; collections for conodonts at 846.7–848.7 m (C-107986), 831.6–833.5 m (C-107985), 762.6–769.0 m (C-107984)	108	851
17	**Dolomite:** argillaceous with siliceous content; very finely crystalline; dark grey and dark brownish grey, weathers yellowish brown, pale brown, greyish orange and light olive grey, platy, recessive; bedding 1–8 cm; some siliceous laminae; at 709.9–710.2 m quartzite laminae predominant; collection for conodonts at 710.8–715.7 m (C-107983)	44	743
16	**Dolomitic limestone** and **limy dolomite:** significant content of fine quartz sand and silt; very finely crystalline; dark grey, weathers greyish orange, yellowish grey and light olive-grey, platy and blocky; bedding 4–20 cm; siliceous laminae at 845.2 m; contact with Lower Member drawn at top of limestone ribs, at presence of quartz silt and sand and at change of weathering colours to greyish orange	28	699
	Lower Member 671 m		
	Limestone unit 135 m (studied at 844NE and 838NE, top outcrops)		
15	**Limestone:** dolomitic; microcrystalline; grey, weathers grey and light grey, resistant; bedding 24–30 cm; forms predominant ribs in ridge at 667–670 m and at 663–664 m separated by recessive slot; with argillaceous dolomitic limestone, microcrystalline olive-brown-grey, weathers very pale yellowish brown, platy with laminae rich in quartz silt; graptolites and cephalopods at 663.9–666.9 m (C-107982)	8	671
14	**Limestone:** microcrystalline; dark grey, weathers dull grey, light grey, light olive-grey, and yellowish grey with some pale yellowish brown bedding planes, blocky and platy; bedding 2–20 cm; very minor limy shale interbeds; rare inarticulate brachiopods and trilobites (C-107993 at 583.1–587.0 m); collections for conodonts at 569.7–572.1 m (C-107972), 561.7–567.2 m (C-104130; 838NE) and 557.3–567.2 m (C-107981; 844NE); contact with middle unit drawn at top of argillaceous limestone and limy shale and change in weathering colours to dull grey and light grey	127	663
	Middle unit 402.5 m (studied at 838NE, supplemented by 843NE and 844/849/925NE for basal and top beds)		
13	**Limestone:** argillaceous; weathers platy and shaly, yellowish grey; several interbedded microcrystalline limestone intervals form ribs, greyish black, weathers dull dark-grey; bedding 30–60 cm; collection for conodonts at 509.0–510.5 m (C-107971)	29.5	536
12	**Limestone:** argillaceous; dark grey; weathers shaly, yellowish grey, olive-grey and grey; bedding 30–300 cm, some lamination; cleavage at angle to bedding; limy shales; minor limestone interbeds, bedding 8–45 cm, weathers blocky; large limestone concretions in shale at 505.3–505.8 m; graptolites (C-107992 at 505.8 m, C-104129 504.7–504.8 m, C-104127 488.0–488.2 m, C-104126 480.0–480.1 m); collection for conodonts at 491.6–491.9 m (C-104128)	27	506.5
11	**Limestone:** microcrystalline; weathers grey, resistant; bedding 15–90 cm	2	479.5
10	**Limestone:** argillaceous; weathers grey and yellowish grey; cleavage at angle to bedding; graptolites (C-104125 at 471.8–471.9 m)	6	477.5
9	**Limestone:** microcrystalline, some with siliceous content; dark grey and dark brownish grey, weathers light olive-grey, yellowish grey, grey and light grey, platy and blocky; bedding 2–30 cm, some lamination; minor argillaceous limestone, cleaved, weathers flaggy; rare limy shale; covered interval at 445–453 m; graptolites (C-104124 at 438.6–438.7 m, C-104123 at 435.6–435.7 m, C-104122 at 431.6–431.7 m, C-107969 at 430.1–430.2 m, C-107968 at 427.9–428.0 m, C-104121 at 426.7–427.0 m, C-104119 at 413.6–415.1 m); collections for conodonts at 436.2–443.2 m (C-107970), 427.3–434.5 m, (C-107967), 422.5–424.3 m (C-104120)	65.5	471.5
8	Covered interval	10.5	406

Unit No.		Unit Thickness (m)	Cumulative Thickness (m)
7	**Limestone:** argillaceous; microcrystalline; dark grey and greyish black, weathers dull grey, light olive-grey, yellowish grey, pale yellowish brown, flaggy; bedding 15–300 m, some beds laminated, poorly fissile at angles to bedding; minor platy microcrystalline limestone; very minor limy shale, dark brownish grey and greyish black, weather similarly; at 335.6 and 272.5 m, notches corresponding to recessive shale; large limestone concretions at 308 m; graptolites C-104118 at 394.4–394.5 m, C-104117 at 373.1–373.2 m, C-104116 at 361.2–361.3 m, C-104115 at 346.9–347.2 m, C-104114 at 335.9–336.2 m, C-104113 at *322.5–322.7 m, C-104112 at 303.9–304.0 m, C-104111 at 299.3–299.4 m*, C-104110 at 298.1–298.3 m, C-104108 at 285.0–281.0 m, C-104107 at 284.1–284.6 m, C-107966 at 280.4–281.0 m, C-107965 at 278.3–278.9 m, C-107964 at 275.2–276.1 m; collections for conodonts at 296.3–298.1 m (C-104109), 272.0–274.6 m (C-107963)	123.5	395.5
6	**Limestone.** microcrystalline; dark grey, weathers dull grey, dark grey, olive-grey, light grey, yellow grey, some beds platy; bedding 0.5–20 cm; a few beds with silty laminae; argillaceous limestone (10 to 50% of unit); dark grey, dark brownish grey, weathers yellowish grey, greyish orange, pale yellowish brown, flaggy; some beds laminated with quartz silt, bedding 0.5–30 cm; at 251 m and elsewhere some large limestone concretions within argillaceous limestone beds; minor limy shale; at 254.5–255 m, laminated bed of oolitic sandstone with well rounded medium- to coarse-grained lime and quartz sand and sparse microcrystalline limestone and cherty mudstone pebbles in limy matrix; at 190 m, sparse thin chert beds; graptolites C-107962 at 270.1–270.7 m, C-107961 at 268.8–269.0 m, C-205946 at 267.5–268.0 m, C-107960 at 267.6–267.7 m, C-107959 at 267.2–267.4m, C-104106 at 265.8–266.1 m, C-111470 at 259.5–260.0 m, C-104105 at 258.5–258.8 m, C-104103 at 252.7–252.8 m, C-104102 at 244.4–244.5 m, C-92600 at 220.1–220.3 m, C-205945 at 193.5–194.3 m; collections for conodonts at 262.7–267.3 m (C-107958), 257.9–258.8 m (C-104104)	84.5	272
5	**Shale:** limy; quartz silt laminae common within lower part of unit; dark brownish grey, pale yellowish brown, weathers pale yellowish brown, light grey, pale purplish grey, dull grey, light olive-grey, pale greyish orange, yellowish grey, recessive; bedding 0.5–7 cm, poorly fissile; minor argillaceous limestone, microcrystalline, dark yellowish brown, weathers very pale yellowish brown; bedding 1–10 cm, poorly laminated; at 151–153 m, coarse-grained quartz sandstone, bedding 15–20 cm, crossbedded; at 153.5 m, sole marks on bedding planes; thin chert beds comprise 5% of 143.6–144.5 m and 15% of 131.1–133.5 m intervals; graptolites, siliceous sponge spicules, *Caryocaris*? C-205944 at 178–178.5 m, C-205943 at 170.2–171.2 m, C-92599 at 166.9–167.2 m, C-205942 at 165–166 m, C-92598 at 151.5–152.4 m, C-92597 at 144.5–144.7 m, C-205941 (float) at 143.0–145.0 m, C-82895 at 137.9–138.8 m, C-107999 at 137.5–138.0 m, C-82894 at 134.0–134.3 m, C-107979 at 131.7–132.0 m, C-92596 at 130.9–131.4 m; collection for conodonts at 130.5–134.7 m (C-107978)	57	187.5
	Cherty quartz siltstone unit 69.5 m (studied at 925NE, supplemented by 849NE, collected for conodonts at 838NE)		
4	**Cherty quartz siltstone:** with dolomite grains, rare quartz sand, and irregular, fine, greyish black mudstone laminae; off-white, dark bluish grey, dark grey, weathers very light grey, dark grey, bluish grey, greyish orange with abundant lichens, resistant; bedding 0.25–60 cm; interbedded silty shale and dolomitic shale comprise up to 10% of unit; prominent resistant beds form top of unit; collections for conodonts at 128.3–130.5 m (C-104101), 124.4–130.5 m (C-107977)	49.5	130.5
3	**Shale and shaly mudstone:** dolomitic with abundant quartz silt laminae; dark brownish grey, weathers dark grey, dark yellowish brown, recessive; bedding 0.25–1 cm; at 75.3 m, 20 cm thick limestone bed, microcrystalline with quartz-silt laminae, dark grey, weathers dull bluish grey; cherty quartz siltstone comprises 20% of 77.4–77.7 m interval; graptolites, siliceous sponge spicules (C-107998 at 75.1–75.2 m)	7	81
2	**Cherty quartz siltstone:** dolomite grains and rare quartz sand, and irregular, fine, greyish black mudstone laminae; dark bluish grey, greyish black, weathers dark grey, bluish grey, yellowish brown, with abundant lichens, resistant; bedding 0.5–2 cm, lenticular, laminated. Interbedded dolomitic shale with quartz silt laminae, comprises 10 to 60% of interval	13	74
	Basal unit 61 m (studied at 925NE supplemented by 849NE).		
1	**Mudstone and shale:** with abundant quartz silt laminae, dark brownish grey, dark grey, weathers dark grey, brownish grey, light brown, greyish orange, purplish grey, recessive; bedding 0.2–0.5 cm; basal beds non-limy; at 52.0–52.4 m, limy quartz sandstone interbedded with siliceous shale; at 47.9–51.2 m, thin greyish black chert beds comprise 5–15% of rocks; at 37.8 m, limestone bed, 4 cm thick; covered intervals at 11.4–11.9 m, 6.4–10.1 m, 0.3–4.0 m; graptolites, siliceous sponge spicules, arthropods (*Caryocaris*?) C-107997 at 12.8–12.9 m, C-82893 at 5.5–6.0 m; basal contact concordant	61	61
	McKay Group (top beds)		
	Limestone: slightly siliceous, microcrystalline with abundant biogenic fragments; dark grey, weathers light grey, mottled yellowish brown, resistant, bedding 2–45 cm; echinoderm, inarticulate brachiopod and trilobite fragments, minute gastropods (C-107996 top 10 cm)		

APPENDIX B
North White River Stratigraphic Section, southeastern British Columbia
Fig. 1(Z), 3, 4, 17

East of North White River, a faulted syncline trends almost due north. In the west limb, an excellent section of the Glenogle Formation (Lower Member, with facies change of uppermost part to the Skoki Formation) outcrops along a northwest- and west-trending ridge crest; dips range from 40° to 70° eastward; beds can be matched across minor faults and folds. The base of the section is at 50°19'N, 115°15'W; measurement was by five-foot staff in 1963 by R.V. Best and G.B. Leech (GSC. 57459 to 57475); in 1964 with definitive measurement by B.S. Norford (64560 to 64583); in 1972 by B.S. Norford and R.J. Ross, Jr., on an adjacent ridge at 50°18.4'N, 115°15'W (C-23467 to C-23472), in 1986 by B.S. Norford (C-92586 to C-92595). Numbers such as 57459 and C-23467 refer to collections and localities recorded in the locality catalogue of the Geological Survey of Canads.

Unit No.		Unit Thickness (m)	Cumulative Thickness (m)
	Skoki Formation (incomplete) **69.5 m**		
27	**Dolomite:** siliceous, very finely to medium crystalline; dark grey, grey, weathers pale greyish orange, pale yellowish brown, light grey, very pale orange; resistant; bedding 30–200 cm, many beds with chert nodules; sponges (64560 at 655.3–658.4 m); section ends at fault	17	659.5
26	**Dolomite:** siliceous, finely to medium crystalline; dark brownish grey, brownish grey, weathers greyish orange, yellowish orange, pale greyish orange, pale yellowish brown; resistant; beds 30–120 cm, dolomite stringers, some beds with up to 2% irregular chert nodules; brachiopods, gastropods, sponges, echinoderm debris (64561 at 635.2–637.6 m)	11.5	642.5
25	**Limestone** and **dolomite**: dolomitic, most are siliceous, microcrystalline to finely crystalline; dark grey, weathers light grey, pale yellowish brown with yellowish grey, pale greyish orange mottling; resistant, beds 10–300 cm; mottling includes wispy argillaceous and silty layers, chert nodules amount to 0.5 to 1% of most beds, large gastropods, sponges, brachiopods, echinoderm debris (64562 at 601.4–602.9 m); contact with Unit 24 gradational, picked at change to thickly bedded dolomitic carbonate	41	631
	Glenogle Formation (Lower Member, including a 12.5 m thick intercalation of Tipperary Quartzite) 590 m		
	Limestone unit 76.5 m		
24	**Limestone:** slightly siliceous and slightly argillaceous in some beds, microcrystalline with some calcisiltite content; dark grey, weathers grey, light brownish grey, pale greyish orange; beds 2–40 cm, some with minor chert nodules; argillaceous limestone (20–30%) as layers, mottles and interbeds, microcrystalline, greyish black, weathers yellowish grey, greyish orange, pale greyish orange. Arenaceous limestone with abundant ostracodes amounts to 40% of 567–569 m interval. Limy shale amounts to 1% of 559–564 m interval, brownish black, weathers dark brownish grey. Stromatolites present in 556–565 m interval. Channelled beds of limestone and limestone-conglomerate at 564 m. Trilobites, inarticulate brachiopods, gastropods, ostracodes, brachiopods, conodonts (64563 float at 572.1–575.5 m, 57475 572.1 m, 64564 568.5–573.9 m, 64565 567.8–568.5 m, 64566 563.3–565.7 m, C-92595 560.1–560.2 m, 57474 559.9 m). Contact gradational with Unit 23	76.5	590
	middle unit 450 m		
23	**Limestone:** argillaceous, greyish black, weathers pale greyish orange, yellowish grey, greyish orange, blocky; beds 8–60 cm, microcrystalline limestone (10–25%) as layers, nodular layers, nodules, dark grey; weathers light grey; minor limy mudstone, recessive; calcite stringers; trilobites, inarticulate brachiopods, graptolites, sponges, brachiopods, conodonts (64567 at 504.4–508.1 m, 57473 at 504.4 m, 64568 at 481.3–482.8 m)	42	513.5
22	**Limestone:** argillaceous, greyish black, weathers light grey, yellowish grey, light olive-grey; beds 1–10 cm, many laminated; limy mudstone (5–10%) weathers yellowish grey, pale greyish orange; inarticulate brachiopods, trilobites, conodonts (64569 at 466.3–471.5 m)	23.5	471.5
21	**Limestone:** argillaceous, siliceous in places; dark brownish grey, greyish black, weathers greyish orange, pale yellowish brown; beds 1–15 cm; microcrystalline limestone (15–30%), dark grey, weathers dull grey, dark grey, light grey; as nodules, layers, nodular layers and 1–8 inch beds; inarticulate brachiopods, rare graptolites, trilobites, echinoderm debris (64570, float at 443.5–446.5 m, 64571 at 434.3–435.3 m, 57472 at 426.7 m); peak of ridge at 438 m	33.5	448

Unit No.		Unit Thickness (m)	Cumulative Thickness (m)
20	**Limestone:** argillaceous, dark grey, dark brownish grey, weathers greyish orange, yellowish grey, recessive; bedding 2–30 cm, some beds laminated; microcrystalline limestone (10–40%) weathers light grey; limy shale (5–25%), with limestone nodules and layers; inarticulate brachiopods common, rare graptolites, brachiopods, trilobites, sponges, conodonts (64572 at 396.2–397.8 m, 57471 at 395 m, C-92594 at 385.0–385.3 m)	30.5	414.5
19	**Limestone:** microcrystalline, some with laminae of quartz silt; dark grey, weathers grey, light grey, platy; beds 0.5–15 cm, some nodular; interbedded limy shale and shaly argillaceous limestone (20–35%), greyish black, weathers yellowish grey; monomict limestone nodule conglomerate present within 383–384 m and 347–348 m intervals; brachiopods, inarticulate brachiopods, trilobites, bryozoans in upper half of unit (57470 at 376.4–37.0 m, 64573 at 373.1–374.0 m)	52	384
18	**Limestone:** argillaceous, some beds dolomitic; dark grey, dark brownish grey, weathers greyish orange, pale yellowish brown, blocky and flaggy, recessive; beds 7–45 cm, some with quartz silt laminae; microcrystalline limestone (10%) as thin beds and concretions; limy shale (5%); sponges, trilobites, brachiopods, graptolites (57469 at 329.5–331.0 m, 57468 talus at 329.5 m, 64574 at 328.0–329.2 m, 64575 at 326.1–326.7 m, C-92593 at 320.02–326.1 m, 57467 at 321.3–321.6 m)	15.5	332
17	**Limestone:** microcrystalline; dark grey, weathers grey, light grey; beds 2–30 cm, some nodular; argillaceous limestone (30–50%), dark brownish grey, weathers yellowish brown; beds 6–30 cm, many laminated; inarticulate brachiopods, sponges (57466 at 316.1–316.4 m)	5	316.5
16	**Limestone:** argillaceous and shaly; dark grey, dark brownish grey, greyish black, weathers greyish orange, yellowish brown, yellowish grey, light olive-grey, recessive, flaggy, blocky and rarely slaty; beds 2–20 cm, some with siliceous laminae; interbedded microcrystalline limestone (mostly 10–20% but locally 30-40%) dark grey, dark brownish grey, weathers light grey, grey, platy; beds 0.5–15 cm and as concretions and nodules; graptolites, inarticulate brachiopods, cephalopods, pelecypods (64576 at 306.3–309.7 m, C-92592 at 285.5–285.8 m, 64577 at 249.9–251.5 m, 57465 at 248.7 m, 64578 at 233.5–234.7 m, C-92591 at 232.9–233.3 m	79	311.5
15	**Limestone:** microcrystalline, some beds slightly siliceous, dark grey, weathers dull grey, platy; beds 1–8 cm, some nodular; interbedded argillaceous limestone (10–40%), dark grey, weathers very pale yellowish brown, yellowish grey, somewhat shaly; with sparse laminae of quartz silt; brachiopods, cephalopods, trilobites, graptolites (64579 at 228.6–232.6 m)	8.5	232.5
14	**Dolarenite:** very fine to fine matrix, 10–40% fine to coarse rounded quartz sand, commonly concentrated in layers, dark grey, weathers yellowish brown and pale brown, resistant; beds 4–25 cm; silica stringers	4	224
13	**Limestone:** microcrystalline, dark grey, weathers dull grey, platy; beds 1–8 cm, some nodular; interbedded argillaceous limestone and limy mudstone (20–35%), some beds with fine quartz silt laminae, dark grey, weathers greyish yellow, greyish orange; inarticulate brachiopods, gastropods, trilobites	18.5	220
12	**Dolarenite:** siliceous, very fine to medium grained, with shell debris and sparse medium to coarse quartz sand commonly concentrated in layers; dark grey, weathers greyish orange, pale yellowish brown, light grey, resistant; beds 2–45 cm; shaly dolomite amounts to 20% of 198–199 m; brachiopods, echinoderm debris (C-92590 at 201.3–201.8 m, 64580 at 195.9–196.2 m, C-92589 at 195.7–195.9 m)	6	201.5
11	**Limestone** and **calcisiltite:** microcrystalline; dark grey, weathers grey, dark grey, light grey, platy; undulatory bedding 1–10 cm, some nodular; rare irregular chert nodules; argillaceous limestone (5–30%) some beds laminated, weathers greyish orange, yellowish grey; at 193–195 m, limy shale (40% of interval), dark greenish grey, weathers yellowish grey; poorly fissile, beds 1–3 cm; brachiopods, echinoderm debris (57464 at 189.6 m)	6.5	195.5
10	**Dolarenite:** 20 to 40% rounded medium to coarse quartz sand; grey, weathers very pale yellowish brown, resistant; wavy bedded, beds 5–40 cm, some laminated; rare, irregular chert nodules	1	189
9	**Limestone and calcisiltite:** microcrystalline, slightly siliceous, dark grey, weathers grey, dark grey, light grey, platy; beds 1–10 cm, a few laminated, some nodular; argillaceous limestone (5–30%), dark brownish grey, weathers pale greyish orange, yellowish grey; some beds laminated; limy shale (up to 5%); basal part with interbedded dolomitic quartz calcarenites, dark grey weathers yellowish brown; beds 5–30 cm, some crosslaminated; inarticulate brachiopods, trilobites	34.5	188
8	**Calcarenite:** with about 30% rounded medium to coarse quartz sand, dark grey, weathers grey, yellowish orange, resistant; beds 8-45 cm. Interbedded microcrystalline limestone and argillaceous limestone	1	153.5
7	**Limestone and calcisiltite:** microcrystalline, some slightly siliceous, dark grey, weathers dull grey, light grey, yellowish grey, platy; beds 1–8 cm, some nodular, some laminated; very limy mudstone and argillaceous limestone (30–50%), some poorly fissile, some with quartz silt laminae, dark grey, weathers greyish orange, yellowish grey, flaggy; minor very limy shale at 149–153 m; cephalopods, graptolites	42.5	152.5

Unit No.		Unit Thickness (m)	Cumulative Thickness (m)
6	**Limy mudstone:** shaly, some beds siliceous; dark grey, dark brownish grey, weathers greyish orange, light brownish grey, olive-grey, yellowish grey, recessive; beds 1–15 cm, many finely laminated with quartz silt; interbedded microcrystalline limestone and calcisiltite (10–35%), dark grey, weathers dark grey, grey, light grey, platy; beds 0.5–8 cm, some nodular; local slump breccias, monomict, within a few beds; calcarenite with rounded quartz sand at 85 m; chert layers and nodules in lower half of unit, amounting to 10% at 80 m; graptolites, trilobites, brachiopods, conodonts, ostracodes, gastropods, echinoderm debris (64581 at 98.8–99.4 m, 57463 at 84.7 m, 57462 at 72.8 m, 57461 at 69.2 m, 64582 at 67.0–70.1 m, 57460 at 66.1 m, C-92588 at 63.6-64.6 m); contact abrupt with Unit 5, apparently conformable	47	110
	Tipperary Quartzite 12.5 m		
5	**Quartzite:** fine- to coarse-grained quartz sand, minor chert and dolomite grains; very pale orange, very light grey, weathers very pale yellowish brown, pale greyish orange-pink with abundant lichens; resistant, thinly bedded at base of unit, thickly bedded in upper part, most beds irregularly laminated (some laminae with dolomitic cement) and crosslaminated; basal part with interbedded limy mudstone, rest virtually all quartzite; contact gradational with Unit 4	12.5	63
	Glenogle Formation (part of Lower Member)		
	basal unit 50.5 m		
4	**Quartz siltstone and fine sandstone:** light brownish grey, weathers greyish orange; bedding 1–3 cm; limy mudstone (40–50%), calcisiltite, thin chert bands	7	50.5
3	**Calcisiltite:** siliceous; dark grey, weathers olive-grey, greyish orange; bedding 1–8 cm; mudstone (30–50%), limy, shaly, dark brownish grey, weathers pale yellowish brown, greyish orange, yellowish grey; poorly fissile, beds 1–30 cm, with siliceous laminae; minor quartz siltstone, rare, thin chert bands; quartz sandstone at 27.0–27.4 m, crosslaminated; graptolites, trilobites, arthropods (*Caryocaris*?), brachiopods, conodonts (C-23472 at 32.9–33.0 m, C-92587 at 30.0–30.5 m, C-23471 at 27.4–27.7 m, 57459 at 22.6 m)	28	43.5
2	**Limy mudstone:** shaly; dark brownish grey, dark grey, weathers pale yellowish brown, pale greyish orange, recessive; poorly fissile, beds 0.5–30 cm, some laminated; minor quartz siltstone, some beds dolomitic, dark grey, weathers dark grey, pale greyish orange; beds 1–5 cm, laminated; thin chert bands; graptolites, trilobites, inarticulate brachiopods (64583 at 8.5–10.7 m)	11.5	15.5
1	**Siltstone:** argillaceous; greyish black, weathers dark grey, light brownish grey, pale yellowish brown, pale greyish orange, recessive; beds about 0.5 cm with abundant quartz silt laminae; minor shale; at 0.5–1.2 m, quartzite, very fine- to coarse-grained, poorly sorted quartz sand; very pale orange, light grey, weathers greyish brown, yellowish brown, dark grey, with abundant lichens; beds 4–15 cm, patches of dolomitic cement in some beds; graptolites (C-92586 at 2.7–3.5 m); contact with McKay Group conformable	4	4
	McKay Group (uppermost beds)		
	Dolomite: siliceous, very finely to finely crystalline; dark grey, weathers dull grey, yellowish brown, light olive-grey, with lichen stains; beds 1–15 cm, some nodular, many laminated; rare chert nodules; brachiopods, cephalopods (C-23467 at 33 m below top, C-23468 at 7.6 m), conodonts (C-23469 from top 7.6 m, C-23470 from top 1.5 m)		

APPENDIX C
Diana Lake and adjacent Judge Peak stratigraphic sections, Brisco Range, southeastern British Columbia
Fig. 1 (F and F'), 3–6, 29, 32–34

Diana Lake is the source of one of the several headwater branches of Pinnacle Creek, the valley of which outlines a sharp anticline, cored by the uppermost part of the McKay Group. The Diana Lake Stratigraphic Section is in the southwest limb with essentially vertical dips. The top 150 m are completely exposed in cliffs below the Mount Wilson Quartzite, but below this, outcrops are limited to discontinuous exposures along the stream and represent a minor part of the stratigraphic interval. Small chevron folds and minor faults can be seen within the Lower Member of the Glenogle Formation in the nearby Judge Peak Section (Fig. 1, F', 5, 6) in the northeast limb of the anticline, and the covered intervals within the measured stratigraphic section could conceal similar folding, and perhaps faults. Thus the thickness of the Lower Member should be considered an approximate figure. Numbers such as C-164526 and 57459 refer to collections and localities recorded in the locality catalogue of the Geological Survey of Canada.

Diana Lake Stratigraphic Section

Measurement was by tape and compass in 1989. The upper and lower contacts had been studied in 1962 and 1987 and collections of graptolites made from isolated outcrops within the Lower Member in 1964 (see Appendix D). The top of the section is in the cliffs above the southeast end of Diana Lake (50°52.5'N, 116°14'W), the base is at a small waterfall on Pinnacle Creek.

Mount Wilson Quartzite 150 m

Basal beds, medium- to coarse- grained **quartzite**, off-white, weathers off-white and creamy light grey with abundant lichen stains, very resistant, bedding 0.3 to 3 m, some beds crossbedded; contact paraconformable above Diana Lake, erosion surface with 10 cm of relief at ridge crest

Glenogle Formation 547 m (approximate thickness)

Upper Member 215 m

Quartz siltstone and quartzite: very fine- to fine-grained, mostly laminated; greyish orange, pale brown and dark yellowish brown, weathers greyish orange and yellowish orange with lichen stains, in resistant beds 9–100 cm thick but composed of many laminae defined by dark layers; many bedding planes with feeding trails; some layers burrowed, some wispy, some truncated, very rare layers finely crosslaminated; pyrites present; very rare laminae with echinoderm and other fine shell debris; shale partings quite rare in top 100 m but amounting to about 15 per cent of basal 50 m; covered intervals present in lower third of Member, contact with Lower Member covered, picked at lowest outcrop of siltstone; in the adjacent Judge Peak Section, the base of the Member is picked at the base of a set of quartz siltstone beds (Unit 11 of that section; Fig. 5, 30, 32) that is prominent in the northeast limb of the anticline but has not been observed to outcrop in the southwest limb

Lower Member 332 m (approximate thickness)

Shale: slaty in some beds limy; dark grey and greyish black, weathers dark grey, grey and greyish brown, recessive (most of the member is represented by covered intervals). Limestone concretions and limestone, some beds argillaceous, interbedded with shale at 210–250 m and also common in basal 2 m; graptolites, caryocarid arthropods, (eleven 1964 collections discussed within the text can be placed in order within a stratigraphic interval 115.5 m thick but cannot be positioned precisely within the Member; another 1964 collection was made from the basal 6 m of the Member; 1987 collection C-164526, 1–2 m above base); contact gradational with McKay Group, picked at dominance of greyish black shale

McKay Group

Top beds, limestone, aphanitic to very finely crystalline, pale olive-grey, weathers light grey, bedding 3 to 30 cm, with about 20 per cent interbedded greyish black slaty shale

Judge Peak Stratigraphic Section

White weathering rocks and talus of the Mount Wilson Quartzite form the crest of Judge Peak in the east limb of the anticline. The stratigraphic section (50°54.3'–54.5'N, 116°13.5'–13.8'W) commences less than a kilometre from the base of the Diana Lake Section and was measured along the crest of the side-ridge of Judge Peak. The strata dip at 52°–57° to the northeast. Only the Lower Member was measured and its thickness is slightly exaggerated by ignoring the effects of two, small, isoclinal folds.

Unit No.		Unit Thickness (m)	Cumulative Thickness (m)
	Mount Wilson Quartzite		
	Basal beds **quartzite:** greyish white, weathers greyish white, resistant; bedding 1–3 m; contact with Unit 13 appears gradational, picked at lowest clean quartzite		
	Glenogle Formation 691 m (approximate thickness)		
	Upper Member 250 m (approximate thickness)		
13	**Quartz sandstone and quartzite:** light grey, weathers pale greyish orange; bedding 15–45 cm, crossbedding common; dolomitic mudstone with dolomitic quartz siltstone and siliceous and argillaceous dolomite that dominates lower part of unit; many beds burrowed or with feeding trails; gradational contact with Unit 12 picked above highest shale	about 150	
12	**Mudstones:** dolomitic with common quartz silt; weathers pale yellowish brown, platy; limy shale common in lower part of unit, rare above; covered interval at 446–449 m; inarticulate brachiopods, graptolites (C-147857 at 449–458.5 m)	about 95	
11	**Quartzite and quartz sandstone:** limy; very fine- to fine-grained; light brownish grey, weathers greyish orange; resistant, bedding 60–90 cm; bases of some beds with flute casts and other sole markings (Fig. 32); boundary between the two members considered to be gradational, picked at lowest significant influx of quartz sand and silt	5	446
	Lower Member 441 m (approximate thickness)		
10	**Shale:** limy; dark grey, weathers yellowish grey and pale orange-grey, recessive, with very minor platy limestone, some argillaceous; bedding 1–5 cm; at 437.15–437.25 m, fine calcarenite bed that includes transported shelly fossils; covered interval at 438–441 m; graptolites, brachiopods, trilobites, conodonts, scolecodonts, ostracodes, bryozoans, gastropods and echinoderm debris (C-147856 at 437.15–437.25 m; C-147855 at 437.00–437.15 m; C-249873 at 432.00–432.20 m); gradational contact with Unit 9 picked at greater proportion of shale and more recessive weathering profile	24	441
9	**Shale:** limy; dark brownish grey, weathers brownish grey and olive-grey; limestone amounts to about 50% of unit, micritic, some beds argillaceous, dark brownish grey, weathers olive-grey and yellowish grey, platy; beds 1–7 cm thick; base gradational with Unit 8, picked at the onset of a high proportion of limestone beds	38	417
8	**Shale:** limy; dark brownish grey and brownish black, weathers light olive-grey, brownish grey, dull olive-grey and dark grey, recessive; bedding 1–2 cm, cleavage at low angle to bedding; limestone beds locally amount to 5 to 15% of strata, micritic to very fine grained, dark brownish grey and grey, weathers dull grey, olive-grey and yellowish grey, platy; bedding 1–20 cm; sparse limestone concretions up to 90 cm in diameter; small isoclinal fold at 240 m, minor fault at 138 m; covered interval at 103–107 m; graptolites (C-249872 at 140.00–140.15 m)	276	379
7	**Limestone:** micritic, slightly argillaceous, dark grey, weathers light grey and pale yellowish grey, platy; bedding 1–5 cm; interbeds of limy shale amount to 25% of unit	8	103
6	**Chert:** greyish black, weathers dark grey and dark brownish grey, recessive; bedding 0.5–1 cm, some beds laminated; interbeds of limy shale amount to 20% of unit; minor platy weathering limestone; graptolites (C-147854 at 83.50–83.75 m)	15	95
5	**Limestone:** micritic; dark grey, weathers yellowish grey, platy; bedding 1–7 cm; interbedded shale amounts to 20–50% of strata; rare, laminated chert; small isoclinal fold at 92 m	20	80
4	**Shale:** non-limy; dark grey, weathers dark brownish grey, recessive; interbedded chert laminae amount to 10% of strata, greyish black, weathers greyish black; rare platy weathering limestone; graptolites in float at 50 m	10	60
3	Covered interval, with float of non-limy shale	15	50
2	**Limestone:** micritic; many beds argillaceous; grey, weathers light grey and light olive-grey; bedding 1–3 cm; minor shale; fragmentary trilobites, small cephalopods	20	35
1	**Shale:** non-limy; dark grey, weathers pale brown, recessive; cleavage at low angle to bedding; limestone interbeds amount to 5% of strata, micritic to very fine-grained, grey, weathers yellowish brown, beds 1–8 cm; fragmentary trilobites	15	15
	McKay Group		
	Top beds, **limestone**: micritic; light olive-grey, weathers pale olive-grey and light grey; minor limy shale interbeds; inarticulate brachiopods, cephalopods, trilobites, minute gastropods, conodonts (C-147853 at 0.00–0.50 m below top; C-147851 at 2–3 m below top)		

APPENDIX D
Faunal Lists

These lists provide data for various collections mentioned within the text that are not otherwise documented in the published literature. Graptolite collections presented in Figure 36 (and documented stratigraphically by Appendix A) are not included but those in Figure 37 are, along with collections of other fossils. The full names of taxa are provided in Appendix E. Numbers such as 47396 and C-107954 refer to Geological Survey of Canada collections (curated in Calgary and Ottawa and registered as GSC localities); UA indicates a University of Alberta collection (curated in Edmonton); CU a Columbia University collection (curated in New York). The letters C to ZZ refer to localities in Figures 1 and 4.

Kicking Horse River, riverbank on south side of river, opposite Glenogle Halt (51°17'30"N, 116°50'W, Fig. 1-E)

Lower Member of Glenogle Formation 0.5-0.6 m structurally above westernmost outcrop	*Dicellograptus* sp. *"Glyptograptus"* sp. *Leptograptus* sp. *Nemagraptus* cf. *N. gracilis* (*Nemagraptus gracilis* Zone)	C-107954

Diana Lake Section (50°52.5'N, 116°14'W, Fig. 1-F, Appendix C)

The Glenogle Formation is about 547 m thick and poorly and discontinuously exposed; a set of collections were sampled from a segment with an unspecified stratigraphic position within the Lower Member (about 332 m thick at the Section) and another set within its basal 6 m.

Upper set of collections		
118.5 m	*Isograptus forcipiformis*	UA
70 m	*Didymograptus* cf. *D. lepidus*	UA
20 m	*Isograptus victoriae divergens* *Paraglossograptus tentaculatus*	UA
16.5 m	*Paraglossograptus tentaculatus*	UA
10 m	*Undulograptus austrodentatus* *Isograptus caduceus nanus* *Paraglossograptus tentaculatus* (all five collections *Paraglossograptus tentaculatus* Zone)	UA
9 m	*Isograptus victoriae divergens* *Isograptus victoriae maximodivergens*	UA
8.5 m	*Isograptus* sp. *Phyllograptus* sp.	UA
8.25 m	*Cardiograptus* cf. *C. morsus*	UA
7.5 m	*Cardiograptus morsus* *Cryptograptus inutilis* *Didymograptus? v-deflexus* *Glossograptus hincksii* *"Glyptograptus"* sp. *Isograptus* sp. *Isograptus* cf. *I. forcipiformis* *Phyllograptus* sp. *Pseudotrigonograptus ensiformis* (all four collections *Cardiograptus* Zone)	UA
6.5 m	*Didymograptus? v-deflexus* *Isograptus* cf. *I. caduceus australis* *Loganograptus* sp. *Skiagraptus gnomonicus*	UA
3 m	*Isograptus caduceus australis* *Isograptus victoriae maximodivergens* *Pseudotrigonograptus ensiformis* (both collections *Cardiograptus* Zone or *Oncograptus* Zone)	UA
Lower set of collections		
(within basal 6 m)	*Clonograptus* sp. *Didymograptus ensjoensis* *D. extensus* *Phyllograptus* sp. *Tetragraptus acclinans* *Tetragraptus approximatus* *Pendeograptus fruticosus*	UA

(1–2 m above base)	*Caryocaris* sp. *Clonograptus* sp. *Pendeograptus* cf. *P. fruticosus* (both collections *Pendeograptus fruticosus-Tetragraptus approximatus* Zone)	C-164526
	Judge Peak Section (50°54.3'N, 116°13.8'W; Fig. 1-F', Table 2)	
Upper Member of Glenogle Formation 449–458.5 m above base	*"Glyptograptus"* sp. echinoderm fragments inarticulate brachiopod undetermined trilobite *Panderodus* sp. *Periodon aculeatus* *Protopanderodus* sp. *Walliserodus* sp.	C-147857
Lower Member of Glenogle Formation 437.15–437.25 m above base	*Dicellograptus* cf. *D. geniculatus* *"Glyptograptus"* cf. *"G." euglyphus* *Hustedograptus* aff. *H. teretiusculus* indeterminate fragment of graptolite stipe echinoderm and bryozoan fragments, small gastropods inarticulate, orthid and other brachiopods harpid and asaphid trilobites *Mendolaspis* aff. *M. salagastensis* *Triarthrus* cf. *T. pacificus* *Trinodus*? sp. ostracodes scolecodonts *Periodon aculeatus* *Protopanderodus* cf. *P. varicostatus* *Spinodus spinatus*	C-147856
Lower Member of Glenogle Formation 437.00–437.05 m above base	*"Glyptograptus"* cf. *"G." euglyphus* bryozoan, small gastropods inarticulate brachiopods orthid and sowerbyellid? brachiopods asaphid trilobite *Mendolaspis* aff. *M. salagastensis* *Robergia* sp. *Triarthrus* cf. *T. pacificus* ostracodes *Ansella jemtlandica* *Diaphorodus* sp. *Panderodus* sp. *Periodon aculeatus* *Protoprioniodus aranda* *Pygodus serra*	C-147855
Lower Member of Glenogle Formation 432–432.2 m above base	*"Glyptograptus"* cf. *"G." euglyphus* (this and the above two collections, *"Glyptograptus" euglyphus* Zone)	C-249873
Lower Member of Glenogle Formation 140–140.15 m above base	*Glossograptus* sp. *Glyptograptus*? sp. *Pseudotrigonograptus* sp.	C-249872
Lower Member of Glenogle Formation 83.50–83.75 m above base	fragment of biserial graptolite	C-147854
Lower Member of Glenogle Formation, float on ridge-crest about 50 m above base	*Didymograptus (Didymograptellus)* cf. *D. bifidus*	not catalogued
McKay Group 0–0.50 m below contact with Glenogle Formation	indeterminate minute gastropods inarticulate brachiopods indeterminate conodonts, simple cones	C-147853
McKay Group 2–3 m below contact with Glenogle Formation	cf. *Ectenolites simplex* cf. *Rioceras dartoni* *"Asaphellus"*? sp. *Presbynileus*? sp. (Ibexian Zones G to H)	C-147851

Unnamed Creek Section (50°34'N, 115°50'W; Fig. 1-K), east slope of Stanford Range, structurally complex, section overturned, Lower Member of Glenogle Formation

476 m	*Glossograptus* sp. (zonation uncertain)	65727
725 m	*Didymograptus extensus linearis* *Isograptus caduceus australis* *Isograptus victoriae maximus-maximodivergens* morph.	65728
744m	*Tetragraptus* sp. *Xiphograptus* cf. *X. svalbardensis*	65729
762m	*Didymograptus extensus linearis* *Phyllograptus angustifolius angustifolius* (all three collections *Isograptus victoriae maximus* Zone)	65730
792 m	*Didymograptus (Didymograptellus) bifidus* *Phyllograptus* sp.	65731
837 m	*Didymograptus* cf. *D. extensus* *Didymograptus (Didymograptellus) bifidus* *Sigmagraptus* sp. *Tetragraptus* sp. *Pendeograptus fruticosus*? *Perissograptus pygmaeus* *Tetragraptus* cf. *T. serra* (both collections *Didymograptus bifidus* Zone)	65732

North fork of Windermere Creek Section (Fig. 1-N), Lower Member of Glenogle Formation

30 m	*Glossograptus acanthus* *Isograptus* sp.	UA
27 m	*Clonograptus* sp. *Glossograptus acanthus* *Undulograptus austrodentatus austrodentatus* (both collections *Paraglossograptus tentaculatus* Zone)	UA
13 m	*Cardiograptus morsus* *Glossograptus acanthus* *Glossograptus echinatus* "*Glyptograptus*" sp. *Isograptus caduceus australis* *Isograptus victoriae divergens* *Oncograptus upsilon* *Tetragraptus* sp.	UA
12 m	*Apiograptus* sp. *Glossograptus acanthus* *Isograptus caduceus australis* *Isograptus victoriae divergens* *Oncograptus upsilon* *Pseudisograptus manubriatus* *Pseudotrigonograptus ensiformis* *Tetragraptus* sp. *Tetragraptus* cf. *T. serra*	UA
11 m	*Pseudisograptus manubriatus*? *Pseudotrigonograptus ensiformis*	UA
9 m	*Apiograptus* cf. *A. crudus* *Isograptus victoriae divergens* *Pseudotrigonograptus ensiformis* *Tetragraptus* sp.	UA
8 m	*Cryptograptus schaeferi* *Isograptus* sp.	UA
2 m	*Cardiograptus morsus* *Pseudotrigonograptus ensiformis* (all six collections *Cardiograptus* Zone)	UA

Pedley Pass Section (50°27'N, 115°46'W; Fig. 1-R; see Norford, 1969, p. 74), thick debris flow at about 24–27 m; this flow is also present near Fig 1-S (see below)

Lower Member Glenogle Formation (top at 40 m, base at zero)

31–39 m	*Acrograptus cognatus* *Bergstroemograptus crawfordi* *Cryptograptus* cf. *C. antennarius* *Cryptograptus schaeferi* *Glossograptus echinatus* *Isograptus forcipiformis* *Loganograptus logani pertenuis* *Paraglossograptus tentaculatus* *Pseudoclimacograptus riddellensis* *Pseudotrigonograptus ensiformis* *Holmograptus* sp. (upper *Paraglossograptus tentaculatus* Zone and *Pseudoclimacograptus decoratus* Zone)	47396
talus at 30m	*Amplexograptus* sp. *Glossograptus* sp. *"Glyptograptus"* sp. *Isograptus caduceus australis* *Isograptus* cf. *I. victoriae maximodivergens* *Loganograptus logani* *Paraglossograptus tentaculatus* *Pseudotrigonograptus ensiformis* *Tetragraptus* sp. *Tetragraptus* cf. *T. bigsbyi* *Tetragraptus* cf. *T. serra* (*Paraglossograptus tentaculatus* Zone)	C-80099
2 m	*Caryocaris* sp. *Cardiograptus morsus* *Clonograptus* sp. *Goniograptus* sp. *Didymograptus* sp. *Didymograptus*? *v-deflexus* *Isograptus caduceus australis* *Isograptus* cf. *I. victoriae maximodivergens* *Isograptus* cf. *I. victoriae victoriae* *Phyllograptus* sp. *Pseudotrigonograptus ensiformis* *Tetragraptus* cf. *T. amii* graptoloid genus 1 of Cooper, 1979 (*Cardiograptus* Zone)	C-80088
	Near northeast spur of Mt. Aeneas, (50°25.75'N, 115°46.75'W; Fig. 1-S)	
debris flow (about 3 m thick) within Lower Member of Glenogle Formation	bryozoans, sponges, gastropods, cephalopods, echinoderm debris, orthid brachiopods, *Anomalorthis*? sp. aff. *Leptellina* sp. cf. *"Plectorthis?" sinuatis* (Whiterockian)	CU
	West of of Figure 1-S, ridge-crest (50°27.3'N, 115°48.3'W)	
Glenogle Formation 3 m interval just below debris flow	*Caryocaris*? sp. *Amplexograptus* sp. *Didymograptus* sp. (extensiform) *Glossograptus* sp. *Undulograptus* cf. *U. austrodentatus americanus* *Isograptus caduceus australis* *Loganograptus logani pertenuis* *Paraglossograptus tentaculatus* *Phyllograptus* sp. *Pseudobryograptus* sp. *Pseudoclimacograptus* sp. *Pseudotrigonograptus ensiformis* *Tetragraptus* sp. *Holmograptus* sp. *Cryptograptus* cf. *C. inutilis* (*Paraglossograptus tentaculatus* Zone)	CU

Akutlak Composite Section (Fig. 1-W, 4, 7, 8, 36; Fig. 36 lists collections of graptolites from the Glenogle Formation, Table 2; Appendix A)

McKay Group top 10 cm	echinoderm and inarticulate brachiopod fragments minute gastropods and nautiloids indeterminate asaphid trilobites *Ampyx*? sp. *Micragnostus* sp. *Bergstroemognathus* sp. *Comuodus*? sp. *Cristodus loxoides* *Diaphorodus* sp. *Drepanodus arcuatus* *Drepanoistodus basiovalis* *Jumudontus brevis* *Paroistodus parallelus* *Prioniodus elegans* *Protopanderodus rectus* *Protopanderodus* sp. *Protoprioniodus* sp. *Rossodus* n. sp. *Scolopodus krummi* *Tripodus*? sp. *Ulrichodina* sp. (*Prioniodus elegans* Zone)	C-107996

North White River Section (Fig. 1-Z, 4, 37; Fig. 37 lists collections of graptolites from the Glenogle Formation; Table 2; Appendix B)

Skoki Formation 655.3–658.4 m	sponges	64560
Skoki Formation 635.2–637.6 m	sponges echinoderm and trilobite fragments undetermined gastropods spp. *Maclurites* sp. *Pararaphistoma*? sp. indeterminate leptaenid brachiopod *Hesperomena canadensis* (*Anomalorthis* Zone)	64561
Skoki Formation 601.4–602.9 m	sponges echinoderm fragments undetermined gastropods straight cephalopod orthid brachiopod *Sowerbyites*? sp. (probably *Anomalorthis* Zone)	64562
limestone unit of Glenogle Formation float on ridge-crest at 572.1–575.5 m	*Maclurites* sp. *Nileus* sp. pliomerid trilobite indeterminate conodonts, simple cones (*Anomalorthis* Zone)	64563
limestone unit of Glenogle Formation 568.5–573.9 m	ostracodes *Maclurites* sp. *Desmorthis?* sp. cheirurinid trilobite *Nileus* sp. *Protopanderodus* sp. indeterminate conodonts, simple cones (*Anomalorthis* Zone)	64564
limestone unit of Glenogle Formation 567.8–568.5 m	*Eoleperditia* sp.	64565
limestone unit of Glenogle Formation 563.6–565.7 m	ostracode echinoderm debris undetermined gastropod straight cephalopod orthid brachiopod *Paralenorthis* sp. *Orthidiella* sp. asaphid and cheirurinid trilobites *Ectenonotus* sp. *Multioistodus compressus* (*Paralenorthis-Orthidiella* Zone)	64566

limestone unit of Glenogle Formation 560.1–560.2 m	sponges undetermined gastropods and trilobites undetermined inarticulate, orthid and sowerbyellid brachiopods *Camarella* sp. *Orthidium*? sp. "*Plectorthis*?" *sinuatis* *Phragmodus flexuosus* indeterminate simple cones (*Paralenorthis-Orthidiella* Zone)	C-92595
limestone unit of Glenogle Formation 559.9 m	ostracode undetermined gastropod *Lingulella*? sp. (large form) *Peraspis* sp.	57474
middle unit of Glenogle Formation 504.4–508.1 m	indeterminate biserial graptolite *Lingulella*? sp. (large form) orthid brachiopod *Ectenonotus* sp. *Peraspis* sp. (*Paralenorthis-Orthidiella* Zone)	64567 and 57473
middle unit of Glenogle Formation 481.3–482.8 m	echinoderm fragments conulariid inarticulate and orthid brachiopods *Carolinites*? sp. *Kawina* sp. *Peraspis* sp. *Ansella jemtlandica* *Multioistodus compressus* *Periodon aculeatus* *Protopanderodus* sp. indeterminate conodonts, simple cones (*Paralenorthis-Orthidiella* Zone)	64568
middle unit of Glenogle Formation 466.3–471.5 m	inarticulate brachiopod *Peraspis*? sp. *Multioistodus compressus*	64569
middle unit of Glenogle Formation, float on ridge-crest at 443.5–446.5 m	conulariid	64570
middle unit of Glenogle Formation 434.3–435.3 m	indeterminate dichograptid *Glossograptus* sp. *Loganograptus* sp. ostracode echinoderm fragments indeterminate inarticulate, orthid and sowerbyellid brachiopods *Paralenorthis* sp. *Cybelurus* sp. *Ectenonotus* cf. *E. whittingtoni* harpidid trilobite *Peraspis*? sp. *Protocalymene*? sp. (*Paralenorthis-Orthidiella* Zone)	64571
middle unit of Glenogle Formation 426.7 m	*Lingulella*? sp. (large form)	57472
middle unit of Glenogle Formation 396.2–397.7 m	*Hindia*? sp. *Glossograptus* cf. *G. hincksii* *Lingulella*? sp. echinoderm fragments indeterminate inarticulate and orthid brachiopods *Protocalymene*? sp. *Ansella jemtlandica* *Drepanoistodus basiovalis* *Histiodella kristinae* *Parapanderodus gracilis* *Periodon aculeatus* *Protopanderodus* sp.	64572
middle unit of Glenogle Formation 395 m	inarticulate brachiopod *Cybelurus* sp. *Ectenonotus* cf. *E. westoni* (*Paralenorthis-Orthidiella* Zone)	57471

middle unit of Glenogle Formation 385.0–385.3 m	indeterminate dichograptid *Undulograptus austrodentatus*? *Undulograptus*? *intersitus* *Paraglossograptus tentaculatus* inarticulate and orthid brachiopods *Lingulella*? sp. asaphid and harpidid trilobites *Carolinites* sp. *Cybelurus* sp. *Nileus*? sp. *Peraspis*? sp. (*Paralenorthis-Orthidiella* Zone and *Paraglossograptus tentaculatus* Zone)	C-92594
middle unit of Glenogle Formation 376.4–378.0 m	echinoderm fragments *Lingulella*? sp. (large form) undetermined pliomerid trilobite *Nileus*? sp. *Peraspis*? sp.	57470
middle unit of Glenogle Formation 373.1–374.0 m	indeterminate asaphid trilobite	64573
middle unit of Glenogle Formation 329.5–331.0 m	indeterminate orthid brachiopods *Cybelurus* sp. harpidid trilobite *Peraspis* sp. (*Paralenorthis-Orthidiella* Zone)	57469
middle unit of Glenogle Formation talus at 329.5 m	*Symphysurus*? sp.	57468
middle unit of Glenogle Formation 328.0–329.2 m	*Didymograptus* sp. (pendent form) Glossograptus horridus *Isograptus caduceus nanus* *I. victoriae divergens* (*Paraglossograptus tentaculatus* Zone)	64574
middle unit of Glenogle Formation 326.1–326.7 m	sponges *Lingulella*? sp. (large form)	64575
middle unit of Glenogle Formation 320.0–326.1 m	*Archaeoscyphia* cf. *A. minganensis* *Calycocoelia*? sp. *Hindia* cf. *H. sphaeroidalis*	C-92593
middle unit of Glenogle Formation 321.3–321.6 m	*Hindia* cf. *H. sphaeroidalis*	57467
middle unit of Glenogle Formation 316.1–316.4 m	*Hindia* cf. *H. sphaeroidalis*	57466
middle unit of Glenogle Formation 306.3–309.7 m	*Glossograptus hincksii* *Isograptus caduceus nanus* *I. caduceus australis* *I. victoria divergens* *Loganograptus logani pertenuis* *Paraglossograptus tentaculatus* (*Paraglossograptus tentaculatus* Zone)	64576
middle unit of Glenogle Formation 285.5–285.8 m	indeterminate dichograptid *Glossograptus acanthus* *Isograptus caduceus australis* *Pseudotrigonograptus ensiformis*	C-92592
middle unit of Glenogle Formation 249.9–251.5 m	*Cryptograptus*? sp. *Glossograptus acanthus* *G.* cf. *G. horridus* *Isograptus* cf. *I. caduceus australis* *I. victoriae divergens* *Tetragraptus* sp.	64577
middle unit of Glenogle Formation 248.7 m	*Diplograptus*? sp. *Isograptus* spp. *Oncograptus upsilon* *Pseudotrigonograptus ensiformis* (all three collections *Oncograptus* Zone or *Cardiograptus*) Zone)	57465

middle unit of Glenogle Formation 233.5–234.7 m	indeterminate biserial graptolite *Didymograptus* sp. (extensiform) *Isograptus* cf. *I. caduceus australis* *I.* cf. *I. caduceus imitatus* I. victoriae divergens *Pseudisograptus manubriatus*	64578
middle unit of Glenogle Formation 232.9–233.3 m	*Cryptograptus* sp. *Didymograptus*? *v-deflexus* *Goniograptus?* sp. *Isograptus victoriae maximodivergens* *Oncograptus upsilon* *Pseudotrigonograptus ensiformis*	C-92591
middle unit of Glenogle Formation 228.6–232.6 m	indeterminate dichograptid *Isograptus victoriae divergens* *Isograptus forcipiformis* cf. *Primitiella* sp. straight cephalopod indeterminate inarticulate brachiopod indeterminate asaphid trilobite *Globampyx sinalae* *Peraspis kolouros* (all three collections *Oncograptus* Zone)	64579
middle unit of Glenogle Formation 201.3–201.8 m	echinoderm fragments indeterminate gastropod *Anomalorthis*? sp. *Diparelasma* 2 spp. *Trigonodus sinuosus*	C-92590
middle unit of Glenogle Formation 195.7–196.2 m	echinoderm fragments *Blastoidocrinus* sp. *Anomalorthis*? sp. *Diparelasma* sp. *Paralenorthis* sp. *Pteracontiodus cryptodens* (both collections *Paralenorthis-Orthidiella* Zone)	64580 and C-92589
middle unit of Glenogle Formation 189.6 m	echinoderm fragments *Diparelasma* 2 spp. (Zone J to *Paralenorthis-Orthidiella* Zone)	57464
middle unit of Glenogle Formation 98.8–99.4 m	*Didymograptus* sp. (extensiform) *Isograptus* sp.	64581
middle unit of Glenogle Formation 84.7 m	echinoderm debris, small ostracodes indeterminate inarticulate and orthid brachiopods and small gastropods indeterminate trilobite *Ilaenus*? sp. *Tripodus*? n. sp. A (middle to late Ibexian)	57463
middle unit of Glenogle Formation 72.8 m	*Xiphograptus* cf. *X. svalbardensis*	57462
middle unit of Glenogle Formation 69.2 m	*Isograptus victoriae maximodivergens* *Loganograptus* sp.	57461
middle unit of Glenogle Formation 67.0–70.1 m	*Didymograptus* cf. *D. nitidus* *Isograptus caduceus imitatus* *Isograptus victoriae maximodivergens* *Pseudotrigonograptus ensiformis*	64582
middle unit of Glenogle Formation 66.1 m	multibrachiate dichograptid *Isograptus victoriae maximodivergens*	57460
middle unit of Glenogle Formation 63.6–64.6 m	indeterminate dichograptid *Isograptus victoriae maximodivergens* (all five collections *Isograptus victoriae maximus* Zone)	C-92588
basal unit of Glenogle Formation 32.9–33.0 m	*Phyllograptus* sp.	C-23472

basal unit of Glenogle Formation 30.0–30.5 m	*Didymograptus* sp. (pendent) *Phyllograptus* sp. (*Didymograptus bifidus* Zone)	C-92587
basal unit of Glenogle Formation 27.4–27.7 m	inarticulate brachiopods *Drepanodus arcuatus* *Drepanoistodus* sp. *Jumudontus gananda* *Oepikodus intermedius* *Paroistodus originalis* *Paroistodus parallelus* *Paroistodus horridus primus*? *Protopanderodus* sp. *Tripodus*? n. sp. A (late Ibexian, probably Blackhillsian)	C-23471
basal unit of Glenogle Formation 22.6 m	indeterminate trilobite *Phyllograptus* cf. *P. typus*	57459
basal unit of Glenogle Formation 8.5–10.7 m	*Didymograptus (Didymograptellus) bifidus* *Peraspis*? sp. (*Didymograptus bifidus* Zone)	64583
basal unit of Glenogle Formation 2.7–3.5 m	*Didymograptus* sp. (pendent) *Phyllograptus typus* *Tetragraptus* cf. *T. serra* (*Didymograptus bifidus* Zone)	C-92586
top 1.5 m of McKay Group	*Drepanoistodus* sp. *D. arcuatus* *Oepikodus intermedius* *Parapanderodus gracilis* *Paroistodus parallelus* *Prioniodus* sp. *Protoprioniodus* sp. *Scolopodus krummi* *Tropodus*? n. sp. A (*Prioniodus elegans* Zone)	C-23470
	Russell Peak Section (50°27'N, 115°15'W; Fig. 1-ZW, 4)	
Skoki Formation? at 260.7–265.7 m in section	*Jumudontus gananda* *Oepikodus communis* *Parapanderodus asymmetricus* *Parapanderodus gracilis* *Protopanderodus gradatus* *Protoprioniodus aranda* *Tropodus australis* (*Jumudontus gananda-Reutterodus andinus* Zone)	C-147474
Skoki Formation? at 158.9–159.3 m in section	*Drepanoistodus* sp. *Juanognathus* sp. *Oepikodus communis* *Protopanderodus* aff. *P. arcuatus* (Late Ibexian)	C-147473
Tipperary Quartzite 3 cm interval	*Didymograptus (Didymograptellus) bifidus*? (*Didymograptus bifidus* Zone)	C-82899
	Near Rock Canyon Creek (50°13.75'N, 115°10.5'W; Fig. 1-ZY)	
limestone unit of Glenogle Formation	ostracode, echinoderm debris *Paralenorthis marshalli* *Orthidiella* cf. *O. carinata* *Orthidium* sp. *Syntrophina*? sp. indeterminate brachiopods and trilobites (*Paralenorthis-Orthidiella* Zone)	C-82891
	Near Rock Canyon Creek (50°13'N, 115°09'W, elevation 2121 m; Fig. 1-ZY)	
limestone unit of Glenogle Formation	echinoderm debris, gastropod ostracode, cephalopod, pelecypod *Orthidiella* 2 spp. *Syntrophina*? sp. *Ectenonotus* cf. *E. whittingtoni* *Protocalymene* sp. (*Paralenorthis-Orthidiella* Zone)	C-137721

	Section southeast of North White River (50°14'N, 115°10'W)	
limestone unit of Glenogle Formation	sponges, gastropods, echinoderm debris *Camarella*? sp. *Paralenorthis marshalli* *Orthidiella* cf. *O. extensa* *Syntrophopsis* sp. *Ectenonotus* sp. *Goniotelina* sp. *Ilaenus* sp. *Pliomerops* sp. *Raymondaspis*? sp. undetermined brachiopods and trilobites *Ribeiria* sp. *Eoleperditia* cf. *E. bivia* (*Paralenorthis-Orthidiella* Zone)	57482
	First section north of North White River (50°26'N, 115°19'W)	
limestone unit of Glenogle Formation talus from top 13 m	*Ectenonotus westoni* *Ilaenus* sp. *Scotoharpes* sp.	C-82898
limestone unit of Glenogle Formation at 198 m in section	echinoderm debris, conularid? *Discoceras*? sp. *Paralenorthis* sp. *Ectenonotus westoni* *Ilaenus* sp. undetermined trilobites and cephalopods	C-147476
limestone unit of Glenogle Formation at 42 m in section	echnoderm debris *Paralenorthis*? sp. "*Plectorthis*?" *sinuatis* Wilson *Ilaenus*? sp. *Sycophantia*? sp. (all three collections *Paralenorthis-Orthidiella* Zone)	C-147475A
middle unit of Glenogle Formation 9 m above Tipperary Quartzite	undetermined brachiopods and trilobites *Didymograptus* sp. (extensiform) *D.* sp. (proximally declined) *Isograptus* sp. (large form) *Pseudisograptus hastatus* (*Isograptus victoriae maximus* Zone)	C-147475
basal unit of Glenogle Formation 11.25–11.5 m above base	inarticulate and articulate brachiopods *Didymograptus (Didymograptellus) bifidus* *Phyllograptus* sp.	C-82897
basal unit of Glenogle Formation 1–1.25 m above base	*Didymograptus (Didymograptellus) bifidus* (both collections *Didymograptus bifidus* Zone)	C-82896
	Second section north of North White River (50°29'N, 115°16'W)	
Skoki Formation? at 177.5–187.5 m in section	*Bergstroemognathus extensus* *Cornuodus*? sp. *Drepanodus* sp. *Drepanoistodus* sp. *Fahraeusodus marathonensis* *Juanognathus variabilis* *Juanognathus* sp. *Oepikodus communis* *Oistodus* aff. *O. multicorrugatus* *Oneotodus costatus* *Periodon*? sp. *Parapanderodus gracilis* *Protopanderodus gradatus* *Protopanderodus* cf. *P. varicostatus* *Protopanderodus* sp. *Protoprioniodus aranda* *Reutterodus andinus* *Toxotodus carlae* indeterminate acodontiform element	C-147472

Skoki Formation? at 167.5–177.5 m in section	*Cornuodus longibasis* *Drepanodus*? sp. *Histiodella*? sp. *Juanognathus variabilis* *Jumudontus gananda* *Oepikodus communis* *Oistodus*? sp. *Protopanderodus elongatus* *Protopanderodus gradatus* *Reutterodus andinus* indeterminate drepanodontiform element (both collections conodont *Jumudontus gananda-Reutterodus andinus* Zone or slightly older)	C-147471
	Third section north of North White River (50°24'N, 115°15'W)	
limestone unit of Glenogle Formation	echinoderm debris undetermined brachiopods *Carolinites* sp. *Ectenonotus* sp. "*Protopliomerops*" *subquadratus* (*Paralenorthis-Orthidiella* Zone)	57559
	Ridge-crest section near Bull River (50°06.75'N, 115°08.5'W)	
basal unit of Glenogle Formation about 30 m above base	*Didymograptus (Didymograptellus) bifidus* *Carolinites* cf. *C. genacinaca genacinaca* (*Didymograptus bifidus* Zone)	C-108000
	Unnamed Creek Section (50°14'N, 115°33'W), 17 km northwest of Akutlak Composite Section; Lower Member of Glenogle Formation, measurements above base	
148 m	indeterminate graptoloid (cf. taxon 1 of Cooper, 1979, p. 92–94) *Isograptus* cf. *I. victoriae divergens*	65117
145 m	scandent biserial graptolite *Didymograptus* aff. *D. nitidus* *Isograptus victoriae maximodivergens* (zonation uncertain, both collections)	65118
144 m	*Didymograptus* sp. (extensiform) *Didymograptus*? *v-deflexus* *Isograptus* cf. *I. caduceus australis* *Isograptus victoriae maximodivergens* *Tetragraptus* cf. *T. serra* *Pseudotrigonograptus ensiformis* *Xiphograptus*? sp. (*Cardiograptus* Zone?)	65119
134–135 m	*Didymograptus* cf. *D. nitidus* *Isograptus* cf. *I. caduceus australis* *Isograptus victoriae maximodivergens* (*Cardiograptus* Zone or *Oncograptus* Zone)	65120
	Tipperary Lake Section (50°40'N, 115°21'W; Fig. 1; *see* Norford, 1969, p. 68)	
basal unit of Glenogle Formation, 36.5–38 m below base of Tipperary Quartzite	*Didymograptus*? sp. (extensiform) *Carolinites* cf. *C. genacinaca genacinaca* *Lachnostoma latucelsum*	57204
basal unit of Glenogle Formation, talus from 0–38 m below base of Tipperary Quartzite	*Didymograptus* cf. *D. bifidus* large inarticulate brachiopod echinoderm plate *Lachnostoma latucelsum* (both collections *Didymograptus bifidus* Zone)	57205
	West of Tipperary Lake (50°40 1/2 N, 115°24'W; Fig. 1)	
limestone unit of Glenogle Formation	sponges, conulariid echinoderm and bryozoan debris *Paralenorthis* sp. *Orthidiella* sp. *Ectenonotus westoni* *Kawina* sp. aff. *Lehua* sp. *Micragnostus*? sp. *Punka* sp. undetermined brachiopods and trilobites (*Paralenorthis-Orthidiella* Zone)	57561

APPENDIX E
Species Register

This appendix lists all species mentioned in the text (all are from the Glenogle Formation except those with the prefix _; some of these are from the Skoki Formation or from the McKay Group, but others are from other parts of Canada or from elsewhere in the world). Other species mentioned or illustrated in the published literature as being from the Glenogle Formation are also included.

Species with asterisks have their type localities in the Glenogle Formation. Citations such as GSC 12506 refer to specimens within the National Type Collection of Invertebrate Fossils of the Geological Survey of Canada. Abbreviations for publications are:

Ja - Jackson, 1964
Jb - Jackson, 1966
K - Kobayashi, 1955
LaJ - Larson and Jackson, 1967
LeJ - Lenz and Jackson, 1986
NJN - this publication
NR - Norford and Ross, 1978
R - Ruedemann, 1947

Graptolites

Acrograptus cognatus (Harris and Thomas, 1935)
Acrograptus cf. *A. gracilis* (Törnquist, 1891)
Amplexograptus differtus Harris and Thomas, 1935
Apiograptus cf. *A. crudus* (Harris and Thomas, 1935)
**Azygograptus canadensis* Ruedemann, 1947 illustrated R Pl. 58, fig. 9–11; no sicula is visible on the holotype (GSC 12506) and the validity of the taxon is very suspect
Bergstroemograptus crawfordi (Harris, 1926) illustrated NJN Pl. 6, fig. 6
Brachiograptus etaformis Harris and Keble, 1932 illustrated NJN Pl. 6, fig. 13
Bryograptus pusillus Ruedemann, 1904 illustrated R Pl. 49, fig. 5, 6; herein assigned to *Pterograptus*
_*Cardiograptus ampulus* (Hsu, 1934)
**Cardiograptus angustifolius* Ruedemann, 1947 illustrated R Pl. 58, fig. 4; LeJ fig. 9R; herein considered a junior synonym of *C. morsus*
**Cardiograptus folium* Ruedemann, 1947 illustrated R Pl. 58, fig. 1, 2; herein considered a junior synonym of *C. morsus*
Cardiograptus morsus Harris and Keble, 1916 illustrated R Pl. 58, fig. 1, 2, 4, Ja fig. 3–10; LeJ fig. 9O, 9R (some as *C. angustifolius* and C. *folium*); NJN Pl. 5, fig. 1
_*Climacograptus bicornis* (J. Hall, 1847)
Climacograptus antiquus bursifer Elles and Wood, 1908 illustrated R Pl. 71, fig. 54; Cooper (1979) assigned Ruedemann's Glenogle specimen to *Diplograptus? decoratus* (now *Pseudoclimacograptus decoratus*)
Climacograptus eximius Ruedemann, 1925 listed by Ruedemann *in* Evans, 1933.
Climacograptus parvus J. Hall, 1868 *nomen nudum*; Berry (1960) concluded the taxon to be *C. phyllophorus* Gurley, 1896
Climacograptus phyllophorus Gurley, 1896
Climacograptus pungens Ruedemann, 1904
Climacograptus riddellensis Harris, 1924 assigned to *Pseudoclimacograptus* by VandenBerg and Cooper (1992)
Clonograptus cf. *C. tenellus* (T. S. Hall, 1907) listed by Ruedemann *in* Walcott, 1924
Corynoides gracilis perungulatus Ruedemann, 1908 illustrated R Pl. 58, fig. 44–46
Corynoides tricornis Ruedemann 1947 illustrated (cf.) R Pl. 58, fig. 47
Cryptograptus antennarius (J. Hall, 1865) illustrated R Pl. 76, fig. 16
**Cryptograptus antennarius gracilis* Ruedemann, 1947 illustrated R Pl. 76, fig. 21, 22
Cryptograptus inutilis (J. Hall, 1865)
Cryptograptus schaeferi Lapworth, 1880 illustrated LaJ Pl. 3, fig. 13, (cf.) 2; NJN Pl. 6. fig. 15
Cryptograptus tricornis (Carruthers, 1858)
Dawsonia cf. *D. campanulata* Nicholson, 1873 listed by Ruedemann *in* Walker, 1926
**Dicellograptus forceps* Ruedemann, 1947 illustrated R Pl. 57, fig. 49, Pl. 63, fig. 5–8
Dicellograptus cf. *D. geniculatus* Bulman 1932 illustrated NJN Pl. 6, fig. 17
Dicellograptus sextans (J. Hall, 1847)
Dicellograptus cf. *D. smithi* Ruedemann, 1908
Dichograptus octobrachiatus (J. Hall, 1858) listed by Ruedemann, 1947
Dichograptus cf. *D. separatus* Elles, 1898 listed by Ruedemann, 1947
_*Didymograptus artus* Elles and Wood, 1901
_*Didymograptus balticus* Tullberg, 1880
Didymograptus (Didymograptellus) bifidus (J. Hall, 1865) illustrated R Pl. 57, fig. 21–28; LeJ fig. 6J (mostly as *D. canadensis* and *D. columbianus* in both publications); NJN Pl. 4, fig. 5, 6
Didymograptus caduceus Salter, 1853 see *Isograptus caduceus australis*
**Didymograptus canadensis* Ruedemann, 1947 illustrated R Pl. 54, fig. 21–24; herein considered a junior subjective synonym of *D. bifidus*
Didymograptus cognatus Harris and Thomas, 1935; see *Acrograptus cognatus*

**Didymograptus columbianus* Ruedemann, 1947 illustrated R Pl. 54, fig. 25–28; LeJ fig. 6J; herein considered a junior subjective synonym of *D. bifidus*

_Didymograptus deflexus Elles and Wood, 1901

Didymograptus ellesae Ruedemann, 1902 listed by Ruedemann, 1947

Didymograptus ensjoensis Monsen, 1937

Didymograptus euodus Lapworth, 1875 illustrated R Pl. 55, fig. 33–35, Pl. 56, fig. 24

Didymograptus extensus (J. Hall, 1858) illustrated NJN Pl. 4, fig. 2

Didymograptus filiformis Tullberg, 1880 listed by Ruedemann, 1947

Didymograptus cf. *D. gracilis* Törnquist, 1891

Didymograptus cf. *D. hirundo* Salter, 1863 listed by Ruedemann, 1947

Didymograptus cf. *D. indentus* (J. Hall, 1865)

Didymograptus lepidus Ni, 1979

Didymograptus extensus linearis Monsen, 1937

_Didymograptus murchisoni (Beck, 1839)

Didymograptus caduceus nanus Ruedemann 1904 listed by Ruedemann, 1947

Didymograptus cf. *D. nitidus* (J. Hall, 1858) illustrated LaJ Pl. 3, fig. 23

"Didymograptus" nodosus Harris, 1926; Archer and Skevington (1973) assigned *nodosus* to *Holmograptus* and more recently the species has been considered to be a junior synonym of *Holmograptus spinosus* (Ruedemann, 1904) by Cooper and Lindholm (1990, Fig. 1) and by VanderBerg and Cooper (1992, p. 74)

**Didymograptus hirundo occidental in* Ruedemann, 1947 illustrated R Pl. 55, fig. 47, Pl. 56, fig. 25

Didymograptus nicholsoni planus Elles and Wood

Didymograptus patulus (J. Hall, 1858) listed by Ruedemann, 1947

Didymograptus nicholsoni planus Elles and Wood, 1901 listed by Ruedemann, 1947

_Didymograptus protobifidus Elles, 1933

Didymograptus saggitticaulis Gurley, 1896 illustrated LaJ, Pl. 3, fig. 7 (as *D.* aff. *D. v-deflexus* Harris, 1924); NJN Pl. 6, fig. 19

Didymograptus serratulus (J. Hall, 1847)

_Didymograptus sichuanensis Ni, 1979 (*in* Mu *et al.*, 1979)

Didymograptus spinosus Ruedemann, 1904 illustrated R Pl. 54, fig. 43–46; Bell (1960) and Archer and Skevington (1973) assigned *spinosus* to *Holmograptus*

Didymograptus cf. *D. subtenuis* (J. Hall, 1847) listed by Ruedemann *in* Evans, 1933

Didymograptus? *v-deflexus* Harris, 1924 illustrated NJN Pl. 5, fig. 6; Williams and Stevens (1988) tentatively assigned the species to *Xiphograptus*

Didymograptus? aff. *D. v-deflexus* Harris 1924 illustrated LaJ Pl. 3, fig. 7; now assigned to *Didymograptus sagitticaulis* (Gurley, 1892).

Didymograptus cf. *D. vicinus* Harris and Thomas, 1938

Didymograptus walcottorum Ruedemann *in* Walker, 1926, cited as *Isograptus walcottorum* by Ruedemann, 1947, p. 153

Didymograptus walkeri Ruedemann *in* Walker, 1926, cited as *Oncograptus walkeri* by Ruedemann, 1947, p. 154

**Diplograptus gladius* Ruedemann, 1947, illustrated R. Pl. 69, fig. 60; this taxon may be related to *Pseudoclimacograptus decoratus* (Harris and Thomas, 1935)

Diplograptus calcaratus incisus Lapworth, 1908 listed by Ruedemann *in* Evans, 1933

Diplograptus inutilis J. Hall, 1865 listed by Ruedemann, 1947

Exigraptus? uniformis Mu *et al.*, 1979 illustrated LeJ fig. 80

Glossograptus acanthus Elles and Wood, 1908

Glossograptus hincksii bispinatus Bulman, 1931

Glossograptus ciliatus Emmons, 1855 illustrated R Pl. 77, fig. 37

Glossograptus ciliatus douglasi Bulman, 1931

Glossograptus echinatus Ruedemann, 1904 illustrated R Pl. 77, fig. 13 as (*Lasiograptus (Hallograptus) echinatus*); NJN Pl. 6, fig. 5

Glossograptus echinatus grandis Ruedemann, 1933 *nomen nudum* listed by Ruedemann *in* Evans, 1933

Glossograptus hincksii (Hopkinson, 1872) illustrated NJN Pl. 6, fig. 8

Glossograptus horridus Ruedemann, 1908 illustrated R Pl. 77, fig. 20–22

Glossograptus hystrix Ruedemann, 1904 listed by Ruedemann *in* Walcott, 1924

**Glossograptus echinatus major* (Ruedemann, 1947) illustrated R Pl. 77, fig. 15; LaJ, Pl. 3, fig. 8

Glossograptus cf. *G. whitfieldi* (J. Hall, 1859)

"Glyptograptus" euglyphus Lapworth, 1880

Glyptograptus dentatus (Brongniart, 1828) listed by Ruedemann, 1947

Glyptograptus dentatus Hall *nomen nudum* listed by Ruedemann, 1947

Glyptograptus teretiusculus (Hisinger, 1840); see *Huestedograptus teretiusculus*

Goniograptus cf. *G. perflexilis* Ruedemann, 1904, listed by Ruedemann, 1947

Goniograptus thureaui postremus Ruedemann, 1902 listed by Ruedemann, 1947

_Holmograptus nodosus (Harris, 1941)

Holmograptus spinosus (Ruedemann, 1904) illustrated R Pl. 54, fig. 43–46 (as *Didymograptus spinosus*); NJN Pl. 5, fig. 12

_Hustedograptus teretiusculus siccatus (Elles and Wood, 1908)

Hustedograptus cf. *H. teretiusculus* (Hisinger, 1840) illustrated LaJ Pl. 3, fig. 4; NJN Pl. 6, fig. 21

**Isograptus caduceus armatus* Ruedemann, 1947 illustrated R Pl. 57, fig. 20–23; herein considered as a junior subjective synonym of *Kalpinograptus ovatus* (T.S. Hall, 1902)

Isograptus caduceus australis Cooper, 1973 illustrated R Pl. 57, fig. 12–14 as *Isograptus caduceus* (Salter, 1853); LeJ fig. 9L, 9I (as *I. caduceus imitatus* Harris, 1933); NJN Pl. 4, fig. 11, Pl. 5, fig. 8

Isograptus caduceus (Salter, 1853) illustrated R Pl. 57, fig. 12–14; see *I. caduceus australis* Cooper, 1973.

Isograptus victoriae divergens Harris, 1933 illustrated R Pl. 57, fig. 48 (as *I. furcula* Ruedemann, 1947); NJN Pl. 4, fig. 12

Isograptus forcipiformis (Ruedemann, 1904) illustrated LaJ Pl. 3, fig. 11; NJN Pl. 6, fig. 9

Isograptus furcula Ruedemann, 1947 illustrated R Pl. 57, fig. 48; Cooper (1973) concluded *furcula* to be a junior subjective synonym of *I. victoriae divergens* Harris, 1933

Isograptus caduceus gracilis Ruedemann, 1947 illustrated R Pl. 57, fig. 15, 16; see *Pseudisograptus gracilis* (Ruedemann, 1947); assigned as *Arenigraptus gracilis* by Maletz and Mitchell (1996)

_*Isograptus victoriae lunatus* Harris, 1933

Isograptus caduceus imitatus Harris, 1933 illustrated LeJ fig. 9I

Isograptus lyra Ruedemann, 1947 illustrated R Pl. 57, fig. 47 (as *I. lyra?*) assigned as *Kalpinograptus lyra* by Maletz and Mitchell (1996)

Isograptus victoriae maximodivergens Harris, 1933 illustrated R Pl. 57, fig. 26–34, 36 (as *I. walcottorum* Ruedemann, 1947); LaJ Pl. 3, cf. fig. 4; LeJ fig. 9N; NJN Pl. 4, fig. 10

Isograptus victoriae maximus Harris, 1933

Isograptus caduceus nanus (Ruedemann, 1904) illustrated LaJ Pl. 3, fig. 12; LeJ fig. 9E

Isograptus ovatus T.S. Hall, 1902 illustrated R Pl. 57, fig. 20–23 (as *I. caduceus armatus* Ruedemann, 1947); assigned to *Kalpinograptus* by VandenBerg and Cooper (1992, p. 85, fig. 7M)

_*Isograptus primulus* Harris, 1933

_*Isograptus* cf. *I. victoriae victoriae* Harris, 1933

Isograptus walcottorum Ruedemann, 1947 illustrated R Pl. 57, fig. 26–34, 36; Cooper (1973) concluded *walcottorum* to be a junior subjective synonym of *I. victoriae maximodivergens* Harris, 1933

Kalpinograptus ovatus (T. S. Hall 1902) illustrated R. Pl. 57, fig. 20–23 (as *Isograptus caduceus armatus* Ruedemann, 1947); NJN Pl. 6, fig. 12

Lasiograptus (*Hallograptus*) *echinatus* (Ruedemann, 1904) illustrated R Pl. 77, fig. 13; see *Glossograptus echinatus*

Lasiograptus (*Hallograptus*) *echinatus major* Ruedemann, 1947 illustrated R Pl. 77, fig. 15; see *Glossograptus echinatus major*

Leptograptus flaccidus (J. Hall, 1865) listed by Ruedemann, 1947

Loganograptus logani (J. Hall, 1858) illustrated LaJ Pl. 3, fig. 18; NJN Pl. 5, fig. 11

Loganograptus logani pertenuis Ruedemann, 1904 illustrated R Pl. 45, fig. 15.

Loganograptus logani tardus Ruedemann, 1924 *nomen nudum* listed by Ruedemann *in* Walcott, 1924 and *in* Walker 1926

Nemagraptus gracilis (J. Hall, 1847) illustrated (cf.) NJN Pl. 6, fig. 20

Nemagraptus exilis linearis Ruedemann, 1908; Finney (1985) concluded *exilis linearis* to be a junior subjective synonym of *N. gracilis*

Oncograptus upsilon biangulatus Harris and Keble, 1916 illustrated R Pl. 58, fig. 6, 7; Ja fig. 3–8, 3–11 (both as *O. divergens* Ruedemann, 1947 and as *O. walkeri* Ruedemann, 1947); NJN Pl. 5, fig. 2, 3

Oncograptus divergens Ruedemann, 1947 illustrated R Pl. 58, fig. 7; Ja fig. 3–11; herein considered a junior subjective synonym of *Oncograptus upsilon biangulatus* Harris and Keble, 1916

_*Oncograptus magnus* Xiao, Xia and Wang, 1985

Oncograptus upsilon T.S. Hall, 1914

Oncograptus walkeri Ruedemann, 1947 illustrated R Pl. 58, fig. 6; Ja fig. 3–8; herein considered to be a junior subjective synonym of *Oncograptus upsilon biangulatus* Harris and Keble, 1916

_*Orthograptus calcaratus* (Lapworth, 1876)

Parabrograptus tribrachiatus Mu and Qiao, 1962 illustrated Jb Tfig. 1A, 1B, 1C and (as aff.) Tfig. 18; LaJ Pl. 3, fig. 1; NJN Pl. 6, fig. 16

Paraglossograptus tentaculatus (J. Hall, 1858) illustrated R Pl. 80, fig. 6–9, ?10 as *Retiograptus tentaculatus*; Ja fig. 3–6; LaJ Pl. 3, fig. 16; NJN Pl. 6, fig. 4

Paraglossograptus typicalis Mu, 1960 illustrated Ja fig. 3–6; LaJ Pl. 3, fig. 16; Rickards (1972) concluded *typicalis* to be a junior subjective synonym of *P. tentaculatus* (J. Hall, 1858)

Pendeograptus crassus (Harris and Thomas, 1938)

Pendeograptus fruticosus (J. Hall, 1858) illustrated NJN Pl. 4, fig. 4

Pendeograptus pendens (Elles, 1898) illustrated LaJ Pl. 3, fig. 14, as *Tetragraptus pendens*; NJN Pl. 6, fig. 7

Perissograptus pygmaeus (Ruedemann, 1904) illustrated NJN Pl. 4, fig. 7, 8.

Phyllograptus angustifolius angustifolius J. Hall, 1858

Phyllograptus anna J. Hall, 1865 listed by Ruedemann, 1947

Phyllograptus ilicifolius J. Hall, 1858

Phyllograptus anna longus Ruedemann, 1947 illustrated R Pl. 53, fig. 36-40

Phyllograptus angustifolius maximus Ruedemann, 1947, listed by Ruedemann, 1947

Phyllograptus typus J. Hall, 1858

Phyllograptus anna ultimus Ruedemann, 1904 listed by Ruedemann *in* Walcott, 1924

Phyllograptus walkeri Ruedemann, 1947 illustrated R Pl. 53, fig. 8

Protistograptus rectus Ruedemann, 1947 illustrated R Pl. 90, fig. 19

Pseudamplexograptus confertus (Lapworth, 1875)

_*Pseudisograptus dumosus* (Harris, 1933)

Pseudisograptus gracilis (Ruedemann, 1947) illustrated R Pl. 57, fig. 15, 16 (as *Isograptus caduceus gracilis*); NJN Pl. 5, fig. 5; Cooper (1973) thought *Pseudisograptus gracilis* to be a junior subjective synonym of *P. hastatus* (Harris, 1933) but later (Cooper and Ni, 1986) considered the two to be separate species; Maletz and Mitchell (1996) considered both species to belong to *Arienigraptus*

Pseudisograptus hastatus (Harris, 1933) assigned to *Arienigraptus* by Maletz and Mitchell (1996)

_*Pseudisograptus jiangxiensis* (Yu and Fang, 1981)

Pseudisograptus manubriatus (T.S. Hall, 1914) illustrated R Pl. 57, fig. 47; NJN Pl. 5, fig. 4, 9

_*Pseudisograptus tau* (Harris, 1933)

Pseudobryograptus incertus Harris and Thomas, 1934 illustrated LaJ Pl. 3, fig. 19; NJN Pl. 6, fig. 3.

Pseudoclimacograptus decoratus (Harris and Thomas, 1935) illustrated R Pl. 71, fig. 54 (as *Climacograptus antiquus bursifer* Elles and Wood, 1908); LaJ Pl. 3, fig. 3 (as *Diplograptus decoratus*); NJN Pl. 6, fig. 10; assigned to *Pseudoclimacograptus* (*sensu lato*) by VandenBerg and Cooper (1992, p. 85, fig. 7BB, 7CC)

Pseudoclimacograptus riddellensis (Harris, 1924) illustrated NJN Pl. 6, fig. 2
Pseudophyllograptus angustifolius (J. Hall, 1858) illustrated R Pl. 53, fig. 6
Pseudophyllograptus angustifolius elongatus (Bulman, 1931) illustrated (cf.) NJN Pl. 6, fig. 11
Pseudotrigonograptus ensiformis (J. Hall, 1858) illustrated R Pl. 76, fig. 58 (as *Trigonograptus ensiformis obtusus* Ruedemann, 1947); LaJ Pl. 3, fig. 15; NJN Pl. 5, fig. 10, Pl. 6, fig. 18
**Pseudotrigonograptus ensiformis obtusus* (Ruedemann, 1947) illustrated R Pl. 76, fig. 58; Rickards (1973) concluded *obtusus* to be a junior subjective synonym of *P. ensiformis* (J. Hall, 1858)
Pseudotrigonograptus ensiformis minor (Mu and Lee, 1958); Rickards (1973) and Williams and Stevens (1988) concluded *P. ensiformis minor* to be a junior subjective synonym of *P. ensiformis* (J. Hall, 1858), despite discrimination of the two by Cooper and Fortey (1982)
Pterograptus pusillus (Ruedemann, 1904) illustrated R Pl. 49, fig. 5, 6 (as *Bryograptus pusillus*); may be conspecific with *Pseudobryograptus incertus* (Harris and Thomas, 1934)
Pterograptus lyricus Keble and Harris, 1934; VandenBerg and Cooper (1992) considered the species as probably a synonym of *P. elegans* Holm 1881
Pterograptus sinicus Mu, 1953
Reteograptus geinitzianus J. Hall, 1859 illustrated NJN Pl. 6, fig. 14
Retiograptus tentaculatus (J. Hall, 1858) R Pl. 80, fig. 6–9, ?10; see *Paraglossograptus tentaculatus*
Skiagraptus gnomonicus (Harris and Keble, 1916)
Strophograptus trichomanes Ruedemann, 1904 listed by Ruedemann *in* Walker, 1926
Tetragraptus acclinans Keble, 1920 illustrated NJN Pl. 4, fig. 3
_Tetragraptus akzharensis Tzaj, 1968
Tetragraptus ami Elles and Wood, 1902 listed by Ruedemann *in* Walker, 1926
Tetragraptus approximatus Nicholson, 1873 illustrated NJN Pl. 4, fig. 1
Tetragraptus bigsbyi (J. Hall, 1858)
Tetragraptus cf. *T. similis bryonoides* (J. Hall, 1865) listed by Ruedemann, 1947, see *T. serra*
Tetragraptus aff. *T. contrarius* Cooper and Fortey, 1982
**Tetragraptus kindlei* Ruedemann, 1947 illustrated R Pl. 50, fig. 6, 7
Tetragraptus bigsbyi latus Hsu, 1934 illustrated LaJ Pl. 3, fig. 17
Tetragraptus cf. *T. lentus* Ruedemann, 1904 listed by Ruedemann *in* Walcott, 1924
Tetragraptus cf. *T. minutus* Geh, 1964
Tetragraptus pendens Elles, 1898 see *Pendeograptus pendens*
Tetragraptus cf. *T. quadribrachiatus* (J. Hall, 1858)
Tetragraptus serra (Brongniart, 1828)
Tetragraptus cf. *T. taraxacum* Ruedemann, 1902 listed by Ruedemann, 1947
Thamnograptus capillaris (Emmons, 1855) illustrated R Pl. 43, figs. 5, 7
Trigonograptus ensiformis (J. Hall, 1858) see *Pseudotrigonograptus ensiformis*
**Trigonograptus ensiformis obtusus* Ruedemann, 1947 illustrated R Pl. 76, fig. 58; see *Pseudotrigonograptus ensiformis obtusus*
Undulograptus austrodentatus americanus (Bulman, 1963)
Undulograptus austrodentatus (Harris and Keble, 1933) illustrated NJN Pl. 6, fig. 1
Undulograptus? intersitus (Harris and Thomas, 1935); referred to *Oelandograptus* by Cooper and Lindholm, 1990 but considered likely to be an *Undulograptus* by VandenBerg and Cooper, 1992
_Undulograptus sinodentatus (Mu and Lee, 1958)
Xiphograptus cf. *X. declinatus* Williams and Stevens, 1988
Xiphograptus cf. *X. svalbardensis* (Archer and Fortey, 1974)

Brachiopods

_Hesperomena canadensis Norford and Ross, 1978 illustrated NR Pl. 1, fig. 1–12, Pl. 2, fig. 7, 8, 11–17
Paralenorthis marshalli (Wilson, 1926)
Orthidiella cf. *O. carinata* Ulrich and Cooper, 1938
Orthidiella cf. *O. extensa* Ulrich and Cooper, 1938
"Plectorthis?" sinuatis Wilson, 1926

Conodonts

_Acodus deltatus Lindström, 1955
Ansella jemtlandica (Löfgren, 1978) illustrated NJN Pl. 1, fig. 1–3
_Cahabagnathus friendsvillensis Bergström, 1971
Coelocerodontus aff. *C. digonius* Sweet and Bergström, 1962 illustrated NJN Pl. 1, fig. 5
_Cornuodus longibasis (Lindström, 1955)
_Cristodus loxoides Repetski, 1982 illustrated NJN Pl. 1, fig. 8
Drepanodus arcuatus Pander, 1856 illustrated NJN Pl. 1, fig. 10–13
Drepanoistodus basiovalis (Sergeeva, 1963) illustrated NJN Pl. 1, fig. 14, 15
_Eoplacognathus suecicus Bergström, 1971
Erraticodon balticus Dzik, 1978 illustrated NJN Pl. 1, fig. 17
_Fahraeusodus marathonensis (Bradshaw, 1969)
_Histiodella altifrons Harris, 1962
_Histiodella holodentata Ethington and Clark, 1981
Histiodella kristinae Stouge, 1984 illustrated NJN Pl. 1, fig. 19, 20
Histiodella minutiserrata Mound, 1965 illustrated NJN Pl. 1, fig. 18

_*Juanognathus variabilis* Serpagli, 1974
Jumudontus brevis Nicoll, 1992 illustrated NJN Pl. 1, fig. 21
Jumudontus gananda Cooper, 1981 illustrated NJN Pl. 1, fig. 22, 23
_*Lenodus variabilis* (Sergeeva, 1963)
Multioistodus compressus Harris and Harris 1965; illustrated NJN Pl. 1, fig. 24, 25
_*Oepikodus communis* (Ethington and Clark, 1964)
_*Oepikodus evae* (Lindström, 1955)
Oepikodus intermedius Serpagli, 1974 illustrated NJN Pl. 1, fig. 26, 27
Oistodus aff. *O. multicorrugatus* Harris, 1962
Oistodus venustus Stauffer, 1935
_*Oneotodus costatus* Ethington and Brand, 1981
_*Parapanderodus asymmetricus* (Barnes and Poplawski, 1973)
Parapanderodus gracilis (Ethington and Clark, 1964) illustrated NJN Pl. 1, fig. 29, 30
Paraprioniodus costatus (Mound, 1965) illustrated NJN Pl. 3, fig. 31
Paroistodus horridus horridus (Barnes and Poplawski, 1973) illustrated NJN Pl. 2, fig. 1, 2
Paroistodus originalis (Sergeeva, 1973) illustrated NJN Pl. 2, fig. 4
Paroistodus parallelus (Pander, 1856) illustrated NJN Pl. 2, fig. 5–8
Paroistodus horridus primus? Albanesi, 1998 illustrated NJN Pl. 2, fig. 3
Periodon aculeatus Hadding, 1913 illustrated NJN Pl. 2, fig. 9–19
Phragmodus flexuosus Mosalenko, 1973 illustrated NJN Pl. 2, fig. 20–24
Plectodina aculeata Stauffer, 1938
_*Prionodus elegans* Pander, 1856 illustrated NJN Pl. 2, fig. 25–29
_*Protopanderodus* aff. *P. arcuatus* (Lindström, 1955)
_*Protopanderodus elongatus* Serpagli, 1974
_*Protopanderodus gradatus* Serpagli, 1974
Protopanderodus rectus (Lindström, 1955) illustrated NJN Pl. 2, fig. 30, Pl. 3, fig. 1
Protopanderodus cf. *P. varicostatus* (Sweet and Bergström, 1966) illustrated NJN, Pl. 3, fig. 2, 3
Protoprioniodus aranda Cooper, 1981 illustrated NJN Pl. 3, fig. 4–6
Pteracontiodus cryptodens (Mound, 1965)
Pygodus serra (Hadding, 1913) illustrated NJN Pl. 3, fig. 7–10
_*Reutterodus andinus* Serpagli, 1974
_*Scolopodus gracilis* Ethington and Clark, 1964; see *Parapanderodus gracilis*
_*Scolopodus krummi* (Lehnert, 1995) illustrated NJN Pl. 3, fig. 11–14
Spinodus spinatus (Hadding, 1913) illustrated NJN Pl. 3, fig. 15
_*Toxotodus carlae* (Repetski, 1981)
Trigonodus sinuousus Mound, 1965 illustrated NJN Pl. 3, fig. 18, 19
_*Tripodus laevis* Bradshaw, 1969
Tripodus? n. sp. A illustrated NJN Pl. 3, fig. 20–30, 32, 33
_*Tropodus australis* (Serpagli, 1974)

Ostracodes

Eoleperditia cf. *E. bivia* (White, 1877)

Crustaceans

Caryocaris curvillatus Gurley, 1896 listed by Ruedemann *in* Walker, 1926
Caryocaris cf. *C. oblongus* Gurley, 1896 listed by Ruedemann *in* Walker, 1926
Caryocaris putillus Ruedemann, 1926 *nomen nudum* listed by Ruedemann *in* Walker, 1926

Trilobites

Carolinites cf. *C. genacinaca genacinaca* Ross, 1951
Ectenonotus westoni (Billings, 1865)
Ectenonotus cf. *E. whittingtoni* Ross, 1967
**Globampyx sinalae* Norford and Ross, 1978 illustrated NR Pl. 2, fig. 4, Pl. 13, fig. 1, 2, 5, 6, 9, 15, 19, 22, 23, 25
Lachnostoma latucelsum Ross, 1951
Mendolaspis cf. *M. salagastensis Rusconi*, 1955
Peraspis aff. *P. erugata* Ross, 1970
**Peraspis kolouros* Norford and Ross, 1978 illustrated NR Pl. 2, fig. 1–3, 5, 6, 9
_*Peraspis lineolata* (Raymond, 1925)
"*Protopliomerops*" *subquadratus* Kobayashi, 1955
_*Telephina americana* (Billings, 1865)
Telephina pacificus (Kobayashi, 1955) illustrated K Pl. 2, fig. 9a, 9b, 10
**Triarthrus pacificus* (Kobayashi, 1955) illustrated K Pl. 7, fig. 14–16
**Trinodus tardiformis* Kobayashi, 1955 illustrated K Pl. 7, fig. 7a, 7b

Cephalopods

cf. *Ectenolites simplex* Flower, 1964

cf. *Rioceras dartoni* Flower, 1964

Sponges

Archaeoscyphia cf. *A. minganensis* (Billings, 1859)

Hindia cf. *H. sphaeroidalis* Duncan, 1879

APPENDIX F

Taxonomic notes on some species of graptolites from the Glenogle Formation

These comments relate to some of the more important species of graptolites from the Glenogle Formation that were figured by Ruedemann in his 1947 monograph. Taxonomic notes on many of his other taxa are included within Appendix E. Synonymies are indicated where appropriate and some taxa are reassigned to different genera. Specimen numbers are those of the National Type Collection of Invertebrate and Plant Fossils, Geological Survey of Canada (GSC), Ottawa; citations such as GSC loc. 7836 refer to collections catalogued by the Geological Survey of Canada.

Didymograptus bifidus (J. Hall, 1865)

Plate 4, figures 5 and 6

Didymograptus canadensis Ruedemann, 1947, p. 328–329, P1. 54, fig. 21–24.
Didymograptus columbianus Ruedemann, 1947, p. 328, P1. 54, fig. 25–28.
Didymograptus canadensis Ruedemann; Lenz and Jackson, 1986, Fig. 6M.
Didymograptus columbianus Ruedemann; Lenz and Jackson, 1986, Fig. 6J.

Ruedemann's types of *Didymograptus canadensis* were reported to come from the 275 ft. level and those of *D. columbianus* from the 419 and 530 ft. levels within Walker's (1926) measured section at the headwaters of Windermere Creek. The two species were established to accommodate, respectively, narrowly stiped and somewhat broadly stiped pendant didymograptids. Both species were recognized by Mu et al., (1979) in the *Didymograptus sichuanensis* subzone of southwest China.

In their detailed documentation of *Didymograptus bifidus* (J. Hall) in western Newfoundland, Williams and Stevens (1988, p. 43) stated:

> "In a single section both wide and narrow forms occur; any one horizon however contains either one or the other, but not both .... It is quite clear that in some populations thecal growth continued throughout astogeny ... while in others growth ceased soon after formation".

Similarly in the Glenogle Formation, the parameters of both *canadensis* and *columbianus* fall within the ranges of *D. bifidus*; *columbianus* is closely comparable to *bifidus* material from Cow Head in Newfoundland, whereas *canadensis* can be matched to broader stiped forms from Western Brook Pond.

Didymograptus hirundo occidentalis Ruedemann, 1947

The holotype GSC 12478 (Ruedemann, 1947, P1. 55, fig. 47) is lost and the paratype GSC 12479 (*ibid.*, P1. 56, fig. 25) appears to be a distal fragment of a large dichograptid; therefore the presence of *Didymograptus hirundo* Salter in the Glenogle Formation is in doubt.

Oncograptus upsilon biangulatus Harris and Keble, 1916

Plate 5, figures 2 and 3

Oncograptus divergens Ruedemann, 1947, p. 355, P1. 58, fig. 7.
Oncograptus walkeri Ruedemann, 1947, p. 354–355, P1. 58, fig. 6.

The taxon *Oncograptus divergens*, based on holotype GSC 12502, was considered by Ruedemann to be allied to *Oncograptus upsilon* (T.S. Hall) from which it differed in its smaller size, less rapid expansion of the proximal end and closer thecal spacing. We have studied the holotype and found its measurements to fall within the limits of *O. upsilon biangulatus* Harris and Keble; therefore *O. divergens* is suppressed. Ruedemann conceived *Oncograptus walkeri* (holotype GSC 12501) as differing from *O. upsilon* in possessing a longer and narrower biserial portion and in having a smaller angle of divergence of the uniserial stipes. However, we consider *divergens* and *walkeri* to be junior synonyms of *Oncograptus upsilon biangulatus*. Both holotypes are thought to be from GSC loc. 7812, which is catalogued as being from above a fault at Windermere Creek.

Cardiograptus morsus Harris and Keble, 1916

Plate 5, figure 1

Cardiograptus folium Ruedemann, 1947, p. 356, P1. 58, fig. 1–3.
Cardiograptus angustifolius Ruedemann, 1947, p. 356–357, P1. 58, fig. 4.

Ruedemann's species *angustifolius* was established on a single specimen (holotype GSC 12503), which was thought to be longer and narrower than the associated *C. folium* (both from GSC loc. 7836 at the 784 ft. level within Walker's (1926) section at the headwaters of Windermere Creek). The species can be considered a junior synonym of *Cardiograptus morsus*. *Cardiograptus folium* Ruedemann, based upon syntypes GSC 12504 and 12505 (missing), was considered by Ruedemann to be worthy of separation from *C. morsus*, being one third smaller and having a "squarish" proximal end. It is our view that the species *Cardiograptus morsus* contains much variation and that *C. folium* also is a junior synonym of *C. morsus*.

Isograptus victoriae divergens Harris, 1933

Plate 4, figure 12

Isograptus furcula Ruedemann, 1947, p. 353, Pl. 57, fig. 48.
Isograptus victoriae divergens Harris; Cooper, 1973, p. 69–70.

Ruedemann's species *furcula* was based on holotype GSC 12489 from the section at the headwaters of Windermere Creek, at the 784 ft. level of Walker's 1926 measurement (GSC loc. 7836); this is within the *Cardiograptus* Zone. Considering the species to be a junior synonym of *victoriae divergens*, Cooper pointed out that, although the stipes are longer and more slender, *furcula* has the characteristic proximal features and the low inclination of the distal thecae shown by *divergens*.

Isograptus victoriae maximodivergens Harris, 1933

Plate 4, figure 10

Isograptus walcottorum Ruedemann, 1947, p. 354, Pl. 57, fig. 26–34, 36.
Isograptus victoriae maximodivergens Harris; Cooper, 1973, p. 65.

Ruedemann's species was based on syntypes GSC 12491-12500 from the section at the headwaters of Windermere Creek, collected between 734 and 946 ft. of Walker's 1926 measurements; this interval includes the *Cardiograptus* Zone and the lower part of the *tentaculatus* Zone. Ruedemann gave no data on the stratigraphic position of the individual syntypes but commented that the species was most common between 780 and 784 ft., that is, within the *Cardiograptus* Zone. We agree with Cooper's assignment of *walcottorum* as a junior synonym of *maximodivergens*.

Isograptus caduceus australis Cooper, 1973

Plate 4, figure 11

Isograptus caduceus (Salter, 1853); Ruedemann, 1947, p. 350–351, Pl. 57, fig. 12–14.

The specimens figured by Ruedemann (GSC 12483–12485) come from Walker's collections (GSC loc. 7861) at the north fork of Windermere Creek. They compare closely in every detail with *I. caduceus australis* Cooper except in the lesser angle of stipe divergence, namely 310° compared to 342° (average) in the Australian material.

Kalpinograptus ovatus (T.S. Hall, 1914)

Plate 6, figure 12

Isograptus caduceus var. *armatus* Ruedemann, 1947, p. 352, Pl. 57, fig. 20–23.

Ruedemann based his description of *armatus* on syntypes GSC 12487 and 12488 collected by Evans from Beard Creek, northwest of Diana Lake and about halfway between there and Glenogle Halt. This isograptid is characterized by a V-shaped rhabdosome, tightly bunched proximal thecae and long apertural spines. It compares closely with the holotype of *Kalpinograptus ovatus*, except that in the holotype the stipes diverge at 305° whereas in the Glenogle material the angle of divergence averages 320° and details of the proximal thecal development are unknown. The species had been considered as an *Isograptus* (Harris, 1933) but was assigned to *Kalpinograptus* by Carter (1989b) and referred to as *Kalpinograptus?* by VandenBerg and Cooper (1992).

Pseudotrigonograptus ensiformis (J. Hall, 1858)

Plate 6, figure 18

Trigonograptus ensiformis (J. Hall); Ruedemann, 1947, p. 447–448.
Trigonograptus ensiformis var. *obtusus* Ruedemann, 1947, p. 448, Pl. 76, fig. 58.
Trigonograptus ensiformis (J. Hall); Larson and Jackson, 1966, Pl. 3, fig. 15.

Ruedemann's taxon *ensiformis obtusus*, based on holotype GSC 12519 from beds within the type locality of the Glenogle Formation (GSC loc. 353), can be regarded as an immature specimen of *Pseudotrigonograptus ensiformis* (J. Hall). Cooper and Fortey (1982) have discussed in detail the history of why *Trigonograptus* should be suppressed in favour of *Pseudotrigonograptus*.

Plate 1

Figures 1-3. ***Ansella jemtlandica*** (Löfgren). 1, lateral view, Sb element, X100, GSC 116890; 2, lateral view, M element, X52, GSC 116891; 3, lateral view, Sa element, X105, GSC 116892; specimens in figs. 1 and 2 from GSC loc. 64572, fig. 3 from GSC loc. C-104130.

Figure 4. ***Bergstroemognathus* sp.** Lateral view, X55, GSC 116893, from GSC loc. C-107996.

Figure 5. ***Coelocerodontus* aff. *digonius*** Sweet and Bergström. Posterolateral view, X100, GSC 116894, from GSC loc.C-104104.

Figures 6, 7. ***Cornuodus*? sp.** 6, inner lateral view, scandodontiform element, X75, GSC 116895; 7, lateral view, symmetrical element, X85, GSC 116896; both specimens from GSC loc. C-107996.

Figure 8. ***Cristodus loxoides*** Repetski. Lateral view, X78, GSC 116897, from GSC loc. C-107996.

Figure 9. ***Diaphorodus* sp.** Lateral view, Sb element, X160, GSC 116898, from GSC loc. C-147855.

Figures 10-13. ***Drepanodus arcuatus*** Pander. 10, lateral view, X38, GSC 116899; 11, lateral view, X45, GSC 116900; 12, lateral view, X48, GSC116901; 13, lateral view, X48, GSC 118902; all specimens from GSC loc. C-107996.

Figures 14, 15. ***Drepanoistodus basiovalis*** (Sergeeva). 14, lateral view, drepanodontiform element, X88, GSC 116903; 15, lateral view, oistodontiform element, X120, GSC 116904; both specimens from GSC loc. 64572.

Figure 16. ***Eoplacognathus* sp.** Oral view, X60, GSC 116905, from GSC loc. C-107970.

Figure 17. ***Erraticodon balticus*** Dzik. Inner lateral view, Sb element, X60, GSC 116906, from GSC loc. C-107986.

Figure 18. ***Histiodella minutiserrata*** Mound. Lateral view, X85, GSC 116907, from GSC loc. C-104104.

Figures 19, 20. ***Histiodella kristinae*** Stouge. 19, lateral view, X140, GSC 116908; 20, lateral view, X132, GSC 116909; both specimens from GSC loc. 64572.

Figure 21. ***Jumudontus brevis*** Nicoll. Lateral view, X65, GSC 116910, from GSC loc. C-107996.

Figures 22, 23. ***Jumudontus gananda*** Cooper. 22, lateral view, X63, GSC 116911, from GSC loc. C-23471; 23, lateral view, X61, GSC 116912, from GSC loc. C-147474.

Figures 24, 25. ***Multioistodus compressus*** Harris and Harris. 24, inner lateral view, Sc element, X97, GSC 116913; 25, lateral view, Sb element, X88, GSC 116914; both specimens from GSC loc. 64568.

Figures 26, 27. ***Oepikodus intermedius*** Serpagli. 26, inner lateral view, P element, X62, GSC 116915; 27, lateral view, P element, X86, GSC 116916; both specimens from GSC loc. C-23471.

Figure 28. ***Panderodus* sp.** Lateral view, X140, GSC 116917, from GSC loc. C-147855.

Figures 29, 30. ***Parapanderodus gracilis*** (Ethington and Clark). 29, lateral view, X123, GSC 116918, from GSC loc. 64572; 30, lateral view, X130, GSC 116919, from GSC loc. C-104104.

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Plate 2

Figures 1, 2. ***Paroistodus horridus horridus*** (Barnes and Poplawski). 1, lateral view, X122, GSC 116920; 2, lateral view, X90, GSC 116921; both specimens from GSC loc. C-107967.

Figure 3. ***Paroistodus horridus primus?*** Albanesi. Lateral view, fragmentary specimen, X80, GSC 116922, from GSC loc. C-23471.

Figure 4. ***Paroistodus originalis*** (Sergeeva). Lateral view, oistodontiform element, X60, GSC 116923, from GSC loc. C-107967.

Figures 5-8. ***Paroistodus parallelus*** (Pander). 5, lateral view, distacodontiform element, X76, GSC 116924; 6, lateral view, oistodontiform element, X79, GSC 116925; 7, lateral view, drepanodontiform element, X79, GSC 116926; 8, lateral view, oistodontiform element, X65, GSC O116927; all specimens from GSC loc. C-107996.

Figures 9-14. ***Periodon aculeatus*** Hadding. 9, inner lateral view, Sb element, X86, GSC 116928; 10, lateral view, Sa element, X88, GSC 116929; 11, lateral view, M element, X80, GSC 116930; 12, lateral view Sd element, X100, GSC 116931; 13, inner lateral view Pb element, X103, GSC 116932; 14, inner lateral view Pa element, X125, GSC 116933; all specimens from GSC loc. C-147855.

Figures 15-17. ***Periodon aculeatus*** Hadding. 15, lateral view, M element, X65, GSC 116934; 16, inner lateral view, Pb element, X83, GSC 116935; 17, inner lateral view, Pa element, X75, GSC 116936; all specimens from GSC loc. 64572.

Figure 18. ***Periodon aculeatus*** Hadding. Inner lateral view, Pa element, X90, GSC 116937, from GSC loc. C-107986.

Figure 19. ***Periodon aculeatus*** Hadding. Inner lateral view, Pa element, X37, GSC 116938, from GSC loc. C-107970.

Figures 20, 21. ***Phragmodus flexuosus*** Moskalenko. 20, lateral view, S element, X84, GSC 116939; 21, lateral view, M element, X108, GSC 116940; both specimens from GSC loc. C-104130.

Figures 22-24. ***Phragmodus flexuosus*** Moskalenko. 22, lateral view, S element, 120, GSC 116941; 23, outer lateral view, P element, X80, GSC 116942; 24, lateral view, M element, X90, GSC 116943; all specimens from GSC loc. C-107972.

Figures 25-29. ***Prioniodus elegans*** Pander. 25, Lateral view, Sd element, X94, GSC 116944; 26, lateral view, Sb element, X90, GSC 116945; 27, posterior view, Sa element, X77, GSC 116946; 28, lateral view, M element, X82, GSC 116947; 29, outer lateral view, Pa element, X88, GSC 116948; all specimens from GSC loc. C-107996.

Figure 30. ***Protopanderodus rectus*** (Lindström). Lateral view, X125, GSC 116949, from GSC loc. C-107977.

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Plate 3

Figure 1. ***Protopanderodus rectus*** (Lindström). Lateral view, X65, GSC 116950, from GSC loc. C-23471.

Figures 2, 3. ***Protopanderodus* cf. *P. varicostatus*** (Sweet and Bergström). 2, lateral view, S element, X60, GSC 116951; 3, inner lateral view, M element, X55, GSC 116952; both specimens from GSC loc. C-147856.

Figures 4-6. ***Protoprioniodus aranda*** Cooper. 4, outer lateral view, Sb element, X84, GSC 116953; 5, outer lateral view, M element, X125, GSC 116954; 6, inner lateral view, M element, X60, GSC 116955; specimens in figs. 4 and 5 from GSC loc. C-107978, specimen in fig. 6 from GSC loc. C-107996.

Figures 7-10. ***Pygodus serra*** (Hadding). 7, oral view, Pa element, X75, GSC 116956; 8, oral view, Pa element, X95, GSC 116957; 9, oral view, Pa element, X100, GSC 116958; 10, outer lateral view, S element, X91, GSC 116959; all specimens from GSC loc. C-147855.

Figures 11-14 ***Scolopodus krummi*** (Lehnert). 11, Lateral view, Sc element, X50, GSC 116960; 12, inner lateral view, Sb element, X50, GSC 116961; 13, inner lateral view, Sd element, X42, GSC 116962; 14, inner lateral view of nearly complete Sb element, X40, GSC 116963; all specimens from GSC loc. C-107996.

Figure 15. ***Spinodus spinatus*** (Hadding). Lateral view, Sb element, X70, GSC 116964, from GSC loc. C-147856.

Figures 16, 17. ***Tricladiodus* sp.** 16, inner lateral view, Sc element, X105, GSC 116965; 17, outer lateral view, Sb element, X100, GSC 116966; both specimens from GSC loc. C-104104.

Figures 18, 19. ***Trigonodus sinuosus*** (Mound). 18, lateral view, Sa element, X100, GSC 116967; 19, inner lateral view, Sc element, X95, GSC 116968; both specimens from GSC loc. C-104104.

Figures 20-28. ***Tripodus*? n. sp. A**. 20, inner lateral view, Sc element, X48, GSC 116969; 21, inner lateral view, Sb element, X71, GSC 116970; 22, lateral view, Sd element, X70, GSC 116971; 23, inner lateral view, M element, X40, GSC 116972; 24, posterior view, Sa element, X44, GSC 116973; 25, inner lateral view, Sc element, X65, GSC 116974; 26, inner lateral view, M element, X48, GSC 116975; 27, posterior view, Sa element, X64, GSC 116976; 28, o

Figures 29, 30, 32, 33. ***Tripodus*? n. sp. A**. 29, anterolateral view, Sd element, X37, GSC 116978; 30, inner lateral view, P? element, X33, GSC 116979; 32, inner lateral view, M element, X34, GSC 116980; 33, outer lateview, P? element, X44, GSC 116981; all specimens from GSC loc. C-23471.

Figure 31. ***Paraprioniodus costatus*** (Mound). Postero-oral view, X80, GSC 16982, from GSC loc. C-107972.

Figure 34. ***Ulrichodina* sp.** Lateral view, X43, GSC 116983, from GSC loc. C-107996.

Figure 35. **Small phosphatic gastropods.** Fused together: representative of common occurrence in topmost McKay Group, lateral view, X44, GSC 116984, from GSC loc. C-107996.

Plate 3

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Plate 4

All magnifications are x2.5 unless stated otherwise.
The two dots by the figures are 5 mm apart.

Figure 1. ***Tetragraptus approximatus*** Nicholson. GSC 94300, Pinnacle Creek, below the waterfall (Fig. 16-1) at the base of the Diana Lake Section, basal 6 m of Glenogle Formation; *P. fruticosus-T. approximatus* Zone.

Figure 2. ***Didymograptus extensus*** J. Hall. GSC 94297, locality and horizon data as for Pl. 4, fig. 1; *P. fruticosus-T. approximatus* Zone.

Figure 3. ***Tetragraptus acclinans*** Keble. GSC 94301, locality and horizon data as for Pl. 4, fig. 1; *P. fruticosus-T.approximatus* Zone.

Figure 4. ***Pendeograptus fruticosus*** (J. Hall). GSC 94312, locality and horizon data as for Pl. 4, fig. 1; *P. fruticosus - T. aproximatus* Zone.

Figure 5. ***Didymograptus (Didymograptellus) bifidus*** (J. Hall). GSC 12470d from GSC loc. 10817, Headwaters of Windermere Creek Section, "275 ft." (Walker collection); *D. bifidus* Zone. Specimen is on the same slab as the syntypes of *Didymograptus canadensis* Ruedemann.

Figure 6. ***Didymograptus (Didymograptellus) bifidus*** (J. Hall). GSC 65448 from GSC loc. 9559, Headwaters of Windermere Creek Section, "414 ft." (Walker collection); *D. bifidus* Zone. Specimen is on the same slab as paratype GSC 12472 of *Didymograptus columbianus* Ruedemann. Figure 6J of Lenz and Jackson, 1986.

Figures 7 and 8. ***Perissograptus pygmaeus*** (Ruedemann). GSC 94307 and GSC 94308 from GSC loc. 65732, Unnamed Creek Section (loc. K); *D. bifidus* Zone.

Figure 9. ***Xiphograptus?*** sp. GSC 94295 from GSC loc. 65119, 114 m within Unnamed Creek Section (50°14'N, 115°33'W); *Cardiograptus* Zone.

Figure 10. ***Isograptus victoriae maximodivergens*** Harris. GSC 94291 from GSC loc. 64582, North White River Section; *I. victoriae maximus* Zone.

Figure 11. ***Isograptus caduceus australis*** Cooper. GSC 94299 from GSC loc. 65728, 725 m within Unnamed Creek Section (loc. K); *I. victoriae maximus* Zone.

Figure 12. ***Isograptus victoriae divergens*** Harris. GSC 94293 from Diana Lake Section, at 9 m within upper set of collections; *P.tentaculatus* Zone.

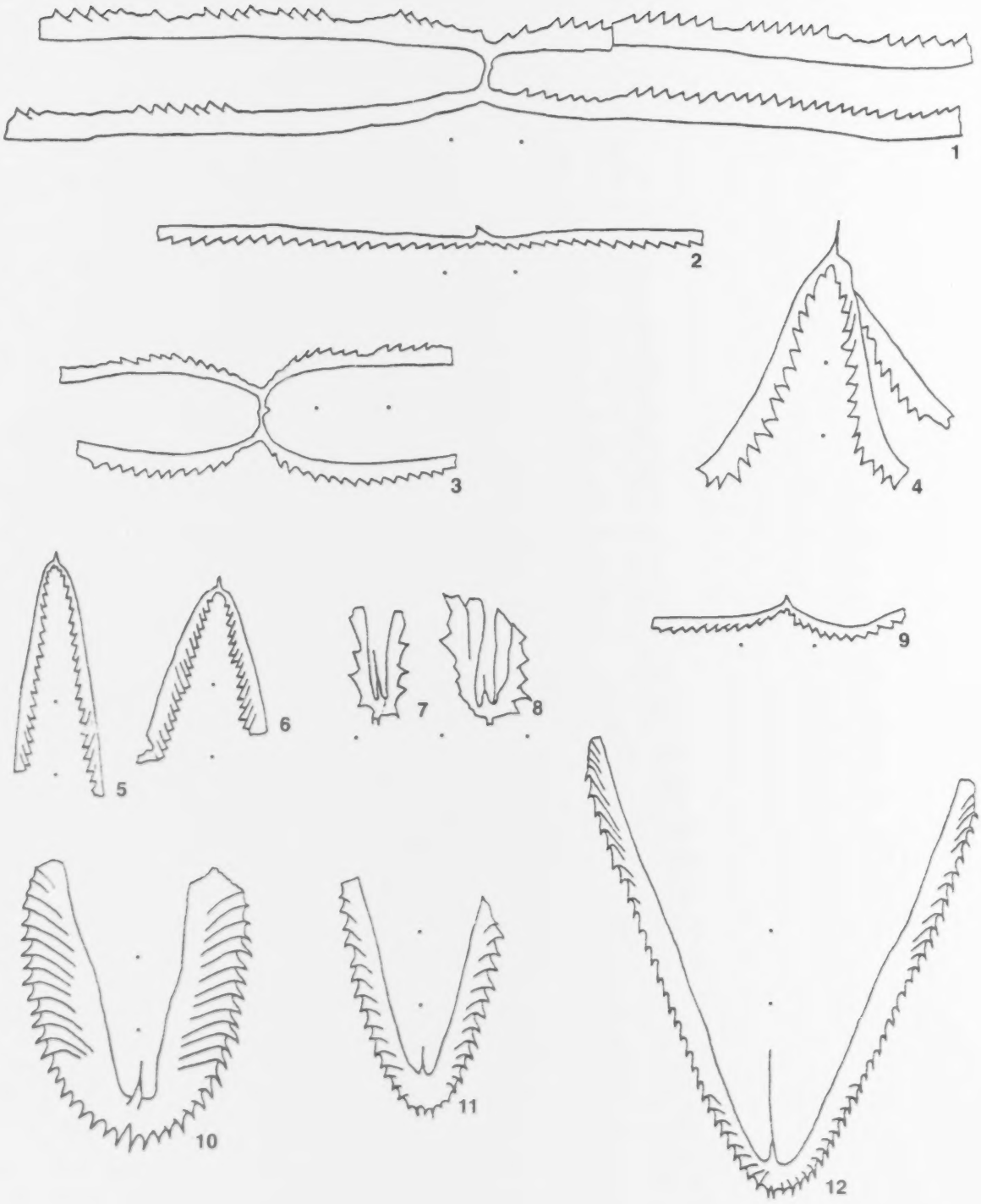
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Plate 5

All magnifications are x2.5 unless stated otherwise.
The two dots by the figures are 5 mm apart.

Figure 1. ***Cardiograptus morsus*** Harris and Keble. GSC 94286, talus, tributary of Pinnacle Creek; probably *Cardiograptus* Zone.

Figure 2. ***Oncograptus upsilon biangulatus*** Harris and Keble. GSC 12501 from GSC loc. 7812, "Windermere Creek, above fault" (Kindle collection); probably *Oncograptus* Zone. Holotype of *Oncograptus walkeri* Ruedemann. Figure 9K of Lenz and Jackson, 1986.

Figure 3. ***Oncograptus upsilon biangulatus*** Harris and Keble. GSC 12502 from GSC loc. 7812, locality and horizon data as for Pl. 5, fig. 2; probably *Oncograptus* Zone. Holotype of *Oncograptus divergens* Ruedemann. Figure 9P of Lenz and Jackson, 1986.

Figure4. ***Pseudisograptus manubriatus*** (T.S. Hall). GSC 94290 from GSC loc. 64578, North White River Section; *Oncograptus* Zone.

Figure 5. ***Pseudisograptus gracilis*** (Ruedemann). GSC 94316 from GSC loc. C-104105, Akutlak Creek Composite Section; *Cardiograptus* Zone.

Figure 6. ***Didymograptus? v-deflexus*** Harris. GSC 94306, Diana Lake Section, at 6½ m within upper set of collections; *Cardiograptus* Zone or *Oncograptus* Zone.

Figure 7. ***Apiograptus*** sp. GSC 94304, at 12 m within North fork of Windermere Creek Section; *Cardiograptus* Zone.

Figure 8. ***Isograptus caduceus australis*** Cooper. UWO 2746, Diana Lake Section, at 3 m within upper set of collections; *Cardiograptus* Zone or *Oncograptus* Zone. Fig. 9L of Lenz and Jackson, 1986.

Figure 9. ***Pseudisograptus manubriatus*** (T. S. Hall). GSC 94318 from GSC loc. C-104103, Akutlak Creek Composite Section; *Oncograptus* Zone.

Figure 10. ***Pseudotrigonograptus ensiformis*** (J. Hall). GSC 94310 from GSC loc. C-92598, Akutlak Creek Composite Section; *I. victoriae maximus* Zone.

Figure 11. ***Loganograptus logani*** (J. Hall). GSC 94311 from loc. 3 of Larson and Jackson 1997, north bank of Kicking Horse River; *P. tentaculatus* Zone; x1.

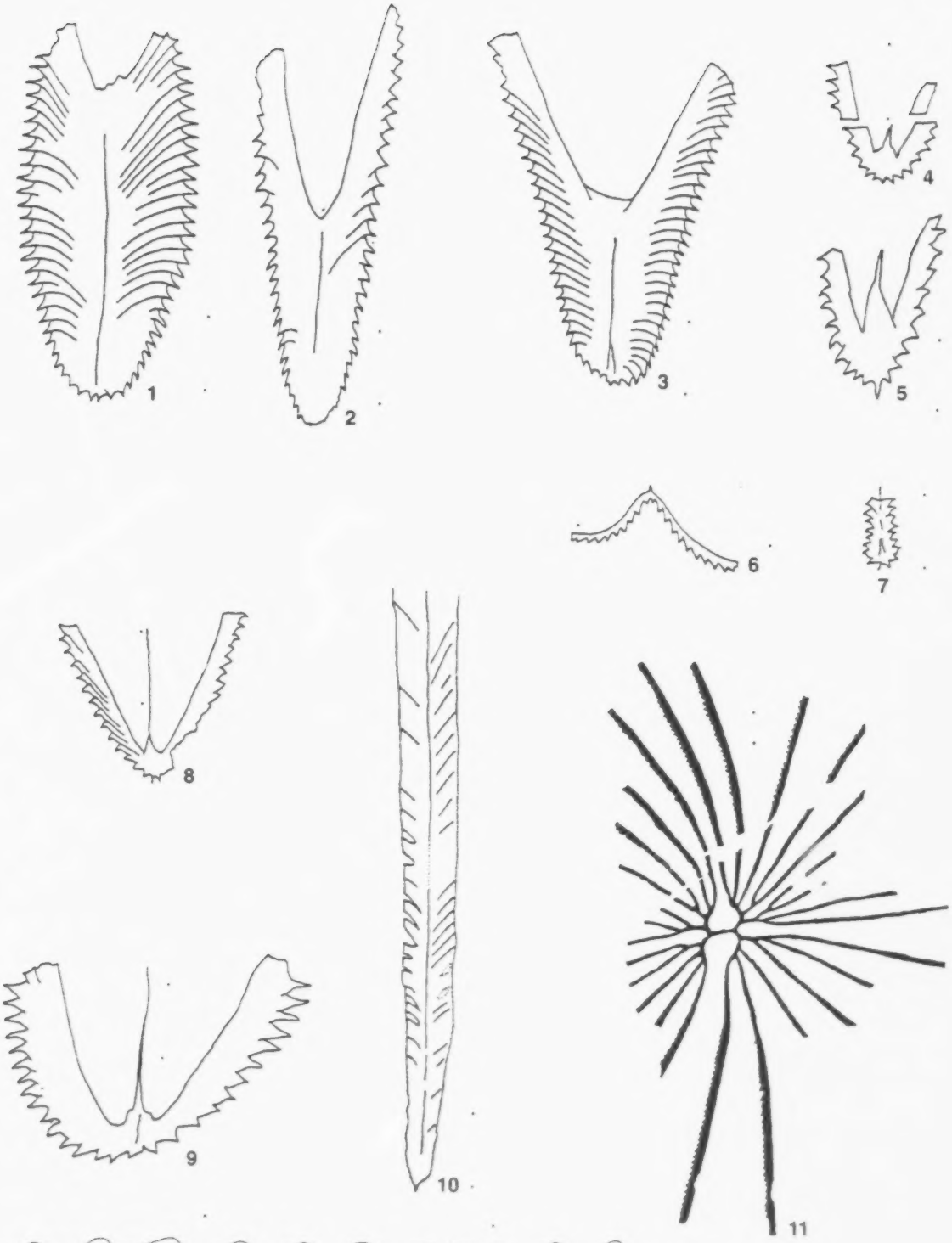
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Plate 6

All magnifications are x2.5 unless stated otherwise.
The two dots by the figures are 5 mm apart.

Figure 1. ***Undulograptus austrodentatus austrodentatus*** (Harris and Keble). GSC 94292, Diana Lake Section, at 10 m within upper set of collections; *P. tentaculatus* Zone.

Figure 2. ***Pseudoclimacograptus riddellensis*** (Harris). GSC 94314 from GSC loc. 47396, Pedley Pass Section; upper *P. tentaculatus* Zone or *P. decoratus* Zone.

Figure 3. ***Pseudobryograptus incertus*** (Harris and Thomas). UA 908, railway cutting (loc. 3 of Larsson and Jackson), north side of Kicking Horse River; *P. tentaculatus* Zone. Pl. 3, fig. 19 of Larson and Jackson, 1967.

Figure 4. ***Paraglossograptus tentaculatus*** (J. Hall). GSC 94313, Diana Lake Section; at 16½ m within upper set of collections; *P. tentaculatus* Zone.

Figure 5. ***Glossograptus echinatus*** Ruedemann. UA 898, same locality and horizon data as Pl. 6, fig. 3; *P. tentaculatus* Zone. Pl. 3, fig. 9 of Larson and Jackson, 1967.

Figure 6. ***Bergstroemograptus crawfordi*** (Harris). GSC 94303 from GSC loc. 47396, Pedley Pass Section; upper *P. tentaculatus* Zone or *P. decoratus* Zone.

Figure 7. ***Pendeograptus pendens*** (Elles). UA 903, same locality and horizone data as for Pl. 6, fig. 3;; *P. tentaculatus* Zone. Pl. 3, fig. 14 of Larson and Jackson, 1967.

Figure 8. ***Glossograptus hincksii*** (Hopkinson). GSC 94319 from GSC loc. C-104107, Akutlak Creek Composite Section; *P. tentaculatus* Zone.

Figure 9. ***Isograptus forcipiformis*** Ruedemann. GSC 94289, Diana Lake Section, at 118½ m within upper set of collections; *P. tentaculatus* Zone.

Figure 10. ***Pseudoclimacograptus decoratus*** (Harris and Thomas). UA 892, railway cutting (DJ-2-62), north side of Kicking Horse River; *P. decoratus* Zone. Pl. 3, fig. 3 of Larson and Jackson, 1967.

Figure 11. ***Pseudophyllograptus*** cf. ***P. angustifolius elongatus*** (Bulman). GSC 94309 from GSC loc. C-104129, Akutlak Creek Composite Section; *P. decoratus* Zone.

Figure 12. ***Kalpinograptus ovatus*** (T.S. Hall). GSC 12488, "Beard Creek, 439 ft. (Evans collection)"; possibly Darriwilian, *P. decoratus* Zone. Syntype of *Isograptus caduceus armatus* Ruedemann.

Figure 13. ***Brachiograptus etaformis*** Harris and Keble. GSC 94315 from GSC loc. C-104121, Akutlak Creek Composite Section; *P. decoratus* Zone.

Figure 14. ***Reteograptus geinitzianus*** J. Hall. UA 881, section ML-1-63, north side of Kicking Horse River; *N. gracilis* Zone. Pl. 3, fig. i of Larson, 1965.

Figure 15. ***Parabrograptus*** aff. ***P. tribrachiatus*** Mu and Qiao. UA 880, at 52½ m within highway section (DJ-1-62), south side of Kicking Horse River; *N. gracilis* Zone. Textfig. 1B of Jackson, 1966.

Figure 16. ***Parabrograptus tribrachiatus*** Mu and Qiao. UA 882, locality and horizon data as for Pl. 6, fig.15; *N. gracilis* Zone. Textfig. 1A of Jackson, 1966; Pl. 3, fig. 1 of Larson and Jackson, 1967.

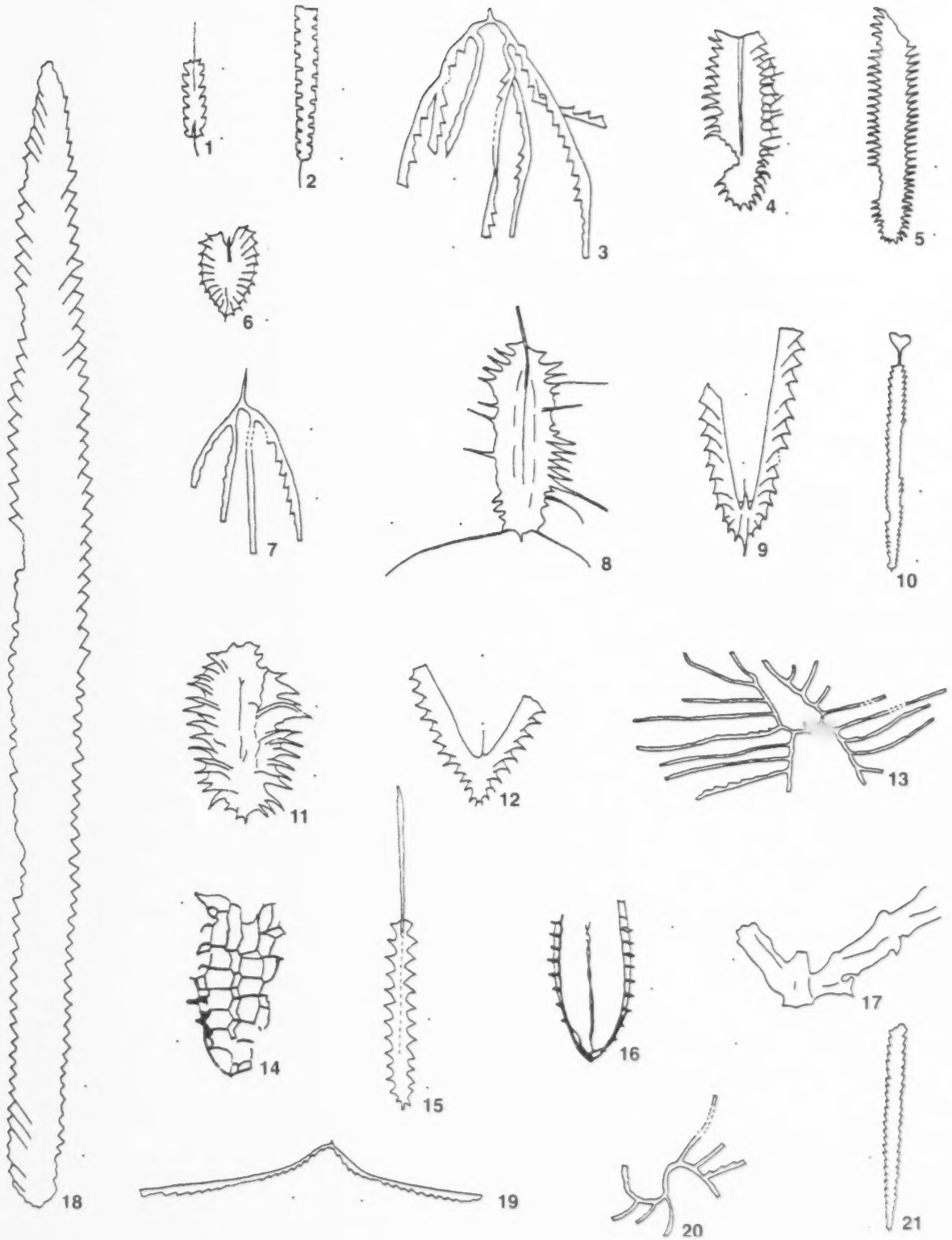
Figure 17. ***Dicellograptus*** cf. ***D. geniculatus*** Bulman. GSC 94317 from GSC loc. C-147856, Judge Peak Section; *"G." euglyphus* Zone. Drawing by S. H. Williams, 1999; x17.

Figure 18. ***Pseudotrigonograptus ensiformis*** (J. Hall). GSC 94294 from GSC loc. C-92598; Akutlak Composite Section; *I. victoriae maximus* Zone. Rhabdosome shows complete thecal outlines.

Figure 19. ***Didymograptus sagitticaulis*** Gurley. UA 896, locality and horizon data as for Pl. 6, Pl. 6, fig. 14; *N. gracilis* Zone. Pl. 3, fig. 7 of Larson and Jackson, 1967 (as *Didymograptus* aff. *D. v-deflexus* Harris).

Figure 20. ***Nemagraptus*** cf. ***N. gracilis*** (J. Hall). GSC 94305 from GSC loc. C-107954, south bank of Kicking Horse River; *N. gracilis* Zone.

Figure 21. ***Hustedograptus*** cf. ***H. teretiusculus*** (Hisinger). UA 893 at 31½-33½ m within highway section (DJ-1-62), south side of Kicking Horse River; *N. gracilis* Zone. Pl. 3, fig. 4 of Larson and Jackson, 1967.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